JPRS 75002

25 January 1980

West Europe Report

SCIENCE AND TECHNOLOGY

No. 12

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service, Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semi-monthly by the National Technical Information Service, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Indexes to this report (by keyword, author, personal names, title and series) are available from Bell & Howell, Old Mansfield Road, Wooster, Ohio 44691.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. JPRS 75002	2.	3. Recipient's Accession No.
4. Title and Subtitle WEST EUROPE REPORT: SCIENCE AND TECHNOLOGY No. 12			5. Report Date 25 January 1980
			6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Joint Publications Research Service 1000 North Glebe Road Arlington, Virginia 22201			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address As above			13. Type of Report & Period Covered
			14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This report contains information on national-level science policies, technology strategies, and research and development programs in West European science and technology in general and specifically in civil technology, with particular attention to transportation, energy, chemical manufacturing, industrial automation and technology transfer. The report will focus primarily on France and the Federal Republic of Germany, but will also cover important developments in Italy, the Netherlands, Sweden and other West European countries.

17. Document Analysis a. Descriptors

WEST EUROPE
Science and Technology
Civil Technology
Transportation
Chemical Manufacturing
Industrial Automation
Technology Transfer

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group 01, 07A, 10, 13B, 17

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited Availability Sold by NTIS Springfield, Virginia 22161	UNCLASSIFIED	65
	20. Security Class (This Page) UNCLASSIFIED	22. Price

(See ANSI-Z39.18)

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

JPRS 75002

25 January 1980

WEST EUROPE REPORT

SCIENCE AND TECHNOLOGY

No. 12

CONTENTS PAGE

 [III - WE - 151 S&T]

NEW USES, COMPUTERIZED MANUFACTURE FOR EUROPEAN PLASTICS

Paris L'USINE NOUVELLE in French No 44 1 Nov 79 pp 87-89

[Article by Pierre Laperrousaz]

[Text] Unanticipated (lasting?) business revival at the International Dusseldorf Exhibition. Although few new products were displayed, there were adaptations and diversifications of already known products such as polyurethan prepregs. In respect to machines the microprocessor control was put to use.

The crisis? What crisis? It is difficult to imagine that Europe is at a low ebb in the high-voltage atmosphere of Kunststoff 79 in Dusseldorf. It is true, however, that Germany has been more or less spared. But the visitors milling around the machines exhibited in the 13 buildings of the fair on the banks of the Rhine were not exclusively Germans. This impression of "good business" was strengthened by the declarations of the executives of the larger chemical enterprises. Demand has been aroused again in Western Europe during the first three quarters of 1979. In the case of standard plastics it increased 13 percent, compared to the same period in 1978. In the coming years the rate of plastics growth should be about 3 percent in the European market and 5 percent in the world market. Although for some time "resubstitution" for plastic materials has been feared, this did not happen. According to the German chemists there is another reason for optimism. Since plastics represent only 3-4 percent of the oil demand the supply is not in danger. However, price increases must be expected.

In short, since the last Dusseldorf meeting in 1975 the future is viewed in a brighter light. The future technology is no longer so much involved with the discovery of totally new polymers, but with the adaptation and diversification of already known polymers. Therefore we observe that one of the most remarkable innovations of Kunststoff--the polyurethan prepreg revealed by Bayer--is a result of the adaptation to a known polymer (polyurethan) of a technology which has been under test for a long time in the case of polyesters. The new material is in the form of a sheet placed between two films of polyethylene and which can be preserved several weeks at ambient

temperature. In the manufacture and fabrication the German engineers have copied as much as possible the manufacturing and fabricating techniques for conventional prepregs. The molding is conducted by compression at 125-130°C in the tools used for polyesters, without parting agents to facilitate subsequent painting. According to the Bayer technologists the first tests in a bumper mold were immediately conclusive. Optimization of the material and of its conditions of use has not been completed. After reinforcement with 30 percent glass fibers of 4-5 cm length and addition of mineral fillers the elastic modulus reached 5,000 MPa, as compared to 10,000-12,000 for polyester prepregs and 1,500-2,000 for glass-filled polyurethans molded by the reaction process, i.e. by mixing the two primary components at the time of injection into the mold. Thus, the new material will fill a niche which has not been occupied before.

Kunststoff 79 also boosted again the hopes which polymer producers and machine constructors have entertained in the last few years for polyurethans. Fiberglass reinforced materials, which retain their mechanical properties over a wider temperature range, have been definitely adopted. Fender prototypes are now under study at Bayer and Hennecke (for machines) in cooperation with the automobile industry. These fenders tolerate light shocks without damage because of their elasticity, and weigh 25 percent less than steel fenders.

The First-Rank Industrial Thermoplastics

Many adaptations and diversifications have been developed also in industrial thermoplastics. For example the first among them, polyamide alone, has offered a substantial number of novelties, and each manufacturer strives to adapt his line to that of his competitors:

--At Bayer a polyamide 66 of high impact resistance almost double that of standard PA. The same manufacturer offers a transparent polyamide.

--A super-rigid polyamide 12 (Rilsan) at ATO. This is a grade reinforced with 20-30 percent carbon fibers, whose bending elastic modulus ranges from 8,000 to 12,000 MPa. Other useful properties for mechanical applications are low fricition coefficient, dimensional precision, rapid heat dissipation, and low surface resistance promoting electrostatic charge flow.

Carbon-fiber reinforced thermoplastics appear to interest more and more people. BASF will soon release polyamides, Solvay is introducing an FPV, and formulators such as Eurostar and LNP have marketed polyamides (PA, acetal, PBT, PPS) for some years.

The second most important plastic technology after that of the polyamides is that of the polycarbonates. Varnish-based surface hardening processes increase the scratch resistance of polycarbonates, so that their use is now contemplated for the side windows and headlight lenses of cars, the protective covers of various machines, and in construction. One Porsche line has already been so equipped in Germany, and a few vehicles are under test in France. One of the main polycarbonate producers, Bayer, also presented an [illegible]istatic

variety for use as safety material and in electricity; another one used in food applications, has a very high Vicat point (180°C, compared to 154 for the usual grades) and an improved resistance to hydrolysis; as well as a polycarbonate of high refractive index (1.6) for photographic optics. A new polycarbonate supplier, ATO, must now be added for Orgalan. At this time this substance is imported from Japan, but the goal of ATO is to manufacture it some time in France. Several grades are proposed for injection, extrusion and blow molding, together with glass-fiber reinforced grades.

A newcomer on the European market is the thermoplastic polyester Valox, already marketed for 6 years by General Electric Plastics in the United States. It is a PBT (polybutylene terephthalate). The line comprises the standard material and a VO grade, two glass-fiber reinforced varieties (30 and 15 percent glass fiber) also containing mineral fibers determining a very high resistance to arc creep. Bayer has introduced three types of thermoplastic aromatic polyesters characterized by a Vicat point of 185-186°C, a nonreinforced, VO-class type of good transparency, and two types 30 percent filled with glass fibers, of which one has a very high oxygen index (45). Fluorescent-tube base prototypes and connector bars have been produced. A new material, also of Solvay, is Arylef, a polyacrylate of Japanese origin characterized by its dielectric strength, thermal resistance, and bending strength.

Among the ABS's two new types have been brought out by PCUK. One RT grade combining a relatively high thermal resistance (98°C for the bending temperature at a load of 1.85 MPa) with a very good Izod impact resistance (270-320 J/m). For the second MD grade the impace resistance (280-360 J/m) has been less reduced at the price of a lower theral resistance (94°C). Borg-Warner has completely renewed its line with about ten ABS varieties offering various combinations of thermal and impact resistance, surface condition and moldability, and also new varieties of lighter-weight materials.

In respect to fabricating machines is to be the microprocessor exhibition. This was expected and many manufacturers (more than ten) have followed into the steps of the French dK-Codim which presented for the first time a microprocessor- controlled injection press at Europlastique 78. This microprocessor is now in general use in polyurethan extrusion and molding. In this connection plastics fabrication is not merely following the electronic "fashion". The microprocessor introduces definite advantages in comparison to the previously dominant cable logic systems, such as easy adjustment process change by modification of a program stored in a memory, and possible checking of a very large number of adjustment parameters and their storage on a magnetic medium (card or tape) for subsequent manufacture without cabling modification. And, compared to a standard computer, the low-cost and compact microprocessor provides for the decentralization of the control in each machine of a plant, the central station providing for monitoring and control.

However, most of the systems displayed at K9 do not fully utilize the microprocessor possibilities. The microprocessor is used primarily to input adjustment parameters (path, pressure and speed curves, switching, holding pressure, temperature, etc.), to monitor them with an alarm triggered on

exceeding of the nominal values, and to diagnose breakdowns and defects. Few of these systems (dK-Codim, IPC (industrial process control), Barber-Coleman (Maco IV system), Krupp Reifenhauser, etc.) use closed-loop adjustment, or the method is proposed as an option with the addition of a standard electronic valve. The number of second-degree adjusting systems is even smaller. In this case a parameter is controlled with a closed loop in response to a nominal value, but also the value is modified automatically in response to the variations of other parameters. For example, the dK-Codim and the IPC systems modify the nominal value to pass to the holding pressure in response to the variations in the viscosity of the matieral according to a stored empirical equation or algorithm.

One criticism of many systems applies to their lack of legibility. Some control panels bring to mind a page of hieroglyphs rather than a shop console. Often the operator must call for the parameters which he wants to verify or change with a selection key (Engel, Sandretto, Krauss Maffei). These parameters appear successively on a luminescent diode dial, so that it is impossible to obtain a general view of the machine operation. In other systems (Billion, Windsor, Demag, Stork, Barber-Coleman) the parameters are displayed on a cathode-ray screen and grouped into "pages" (injection page, closing-opening, temperature, etc.). But it is not certain that the cathode-ray screen has been truly accepted in shops.

After the parameters of a mold/material pair have been stored the adjustment of the machine on resumption of manufacture is very rapid.

Mold Changing Must Be Rapid

Mold changing must not take hours. In this sense Krauss Maffei presented a rapid mold-changing system. In the case of a 210-ton mahcine, assuming fifty changes per year, the system would save 112 hours.

The microprocessor has also been applied to polyurethan fabricating machines (Bayer, Cannon, Elatogran). It governs all the process parameters with a closed loop (component ratio, temperature, pressure), and controls the molding sequences during injection and mold motion. Possible modifications or corrections are introduced by a keyboard. In each cycle (at Cannon a bumper is molded in one minute and eight seconds) the calculator indicates the weight of the casting, the component ratio and density, and the temperature and pressure. It stops the machine when a nominal value (weight of casting) is exceeded.

9456
CSO: 3102

SUCCESSFUL GEOTHERMAL RESEARCH DRILLING REPORTED

Hamburg DIE ZEIT in German 14 Dec 79 p 62

[Article by Horst Rademacher: "Hot Water From Dry Rock"]

[Text] The Valle Grande Basin at the southern border of the Rocky Mountains is still bathed in the morning sun. The dew glistens on the grass at almost 3,000 m altitude. The scene is peaceful, just as if bisons were still grazing here as in earlier times and as if the Indians were still living here in their wigwams.

Now pressure is to be put on the energy crisis in this peaceful valley in the U. S. state of New Mexico, 50 miles from the state capital Santa Fe. At first, however, it was the Pueblo Indians who put the heat on the researchers of the Los Alamos Scientific Laboratory. The Indians did not wish to have their peace disturbed by drillings, machines and humans and bruskly blocked the scientists' right of utilizing the water. The researchers detoured to Fenton Hill, the western edge of the reservation, and the volcano.

The volcano is the focal point of interest to the geologists from Los Alamos. Approximately 14 million years ago it was supposedly active for the last time. Its vents raised magma to the surface. The Valle Grande, similar to the Laacher See in the Eastern Eifel mountains, was formed when the uppermost strata of the earth's crust yielded, because too much magma had been flowing from the interior of the earth through the volcanoes. The geologists call such breakdown craters "caldera."

At some points in the world, there are volcanoes whose heat warms homes and furnishes steam for driving current generators. Steam from within the earth heats entire settlements in Iceland, drives the turbines of electrical plants in the Italian Larderello, and provides parts of San Francisco with current. Utilizing geothermal heat is not a novelty, it is only a rare occurrence.

Many governments now wish to change this state of affairs in view of the threatening energy shortage. Normal rain water is to be pumped from the earth's surface into lower strata so that it heats up there because the

earth becomes hotter in proportion to its depth. The travelers to the center of the earth whom Jules Verne sent into the depths would almost have paid with their lives because of the heat, and the miners in the coal districts of Ruhr and Saar rivers work especially brief shifts when they work on "hot points of operation." In the normal case, the temperature in the earth's crust increases by 3° every hundred meters. Experts call this the "geothermal depth stage."

The means that, if cold water is pushed down sufficiently deep, it heats up. On the other hand, it will only with considerable difficulty reach a boiling point because the pressure in the interior of the earth increases, and the boiling point rises. Utilization of geothermal heat is optimal in the calculations by experts if the water within the earth's crust is heated to 250°C. At a normal geothermal depth stage, this temperature exists at 7 km depth. Drilling to such depths is extremely expensive, which is why geophysicists are searching for areas below which the earth heats up more rapidly.

In Germany, the Eifel Mountains seem particularly well suited for this. The last volcanoes were active here several thousand years ago. The geoscientists thought that the magma hearth, which could have heated its environment to an above-average degree, must still be somewhere. They therefore drilled in Ochtendung, a small town near Koblenz. However--it did not get quite as hot as expected, the depth stage being actually lower than normal. This cold strike could be explained in the meantime: The volcanism in the area of the Laacher See is so young that the increased temperature could as yet not penetrate to the drilling hole, because rock is a very poor heat conductor.

The work group Geothermics, a joint operation of numerous geoscientists which is financed by the Federal Ministry for Research and Technology, the Commission of the European Community and the German Research Association, continued to search, and finally found two abnormal areas in the FRG. Below Urach in the Swabian Alb and near Landau in the Upper Rhine Valley, the temperatures increase particularly rapidly in proportion to depth. A decision was finally made to set up a research drilling in Urach. Project Director Dr Ralph Haenel from the Lower Saxon Land Bureau for Ground Research explains the goal: "We wanted to know which methods of geophysics indicated heat anomalies. In addition, we wanted to make Frac tests in the drilling hole."

Frac is the American abbreviation for fracture, meaning break. In order to be able to absorb heat economically from rock, the water must flow over the largest possible surface of rocks. If rock is broken at depth, the surface usable for heat exchange is broadened. In the middle of this year, the Urach research drilling could be "concluded"--this is how Haenel paraphrases the fact that there was no money available for further tests. The first results are available now.

What the German scientists tried in Urach, American geophysicists have been testing for quite some time at the Fenton Hill in the Valle Grande with two drillings. One drilling lets cold water flow into the hot depth. In this so-called "geothermal test hole 2" the United States researchers made their first fracture tests. The water was forced in under pressure and broke the rock at low points of the drilling hole. The frac was recorded on the surface by two methods: More water had to be filled into the drilling because the cool wet seeped into the fissures caused by it, and seismographs measured the earthquake-like vibrations when the rock broke.

William Laughlin, the group head for Fenton Hill, remembers that "the problem was to determine how the fissures are located so that the second drilling could be started appropriately." The second drilling is necessary in order to bring the heated water back to the surface. Therefore, the drilling engineers tried to match the fissure system created by the pressure in the first drilling hole with a second hold in order to allow water circulation. After some problems, they succeeded in their endeavors.

Heating for the water lies below the Fenton Hill at a depth of 2,700 m, where the rock has a temperature of 187°. Heat was removed from the water pumped in in a heat exchanger at the earth's surface and transferred to a second cycle for utilization. In a trial run of 75 days, the Los Alamos scientists increased the heat power to 5 megawatts. The water coming from the depth showed here 132° in a primary cycle.

On the other hand, compared to this the Urach temperatures are ridiculously low. In the best case, the water pumped in heated from 11 to 22°. This cannot overcome any energy crisis if there should be one. However, as Ralph Haenel emphasizes, this was not the goal of the research project costing DM 15 million marks, which was to clarify basic geophysical problems.

Different from the American hot dry rock method with two drilling holes, only one drilling was sunk in Urach. The project is called hot dry rock because water is pumped into hot, dry rock in order to absorb earth heat there. Although they had only one drilling hole, the German geophysicists started a water cycle. The trick was to break the rock at two points in the drilling hole. The fractures occurred at 25 m distance at a depth of 3,300 m, and crossed not too far away from the drilling hole. The water cycle, on the other hand, succeeded only when a second, thinner pipe was brought into the depth through the original drilling.

The water flowed downwards through the outside pipe, penetrated through the upper fracture into the rock and was heated there. Subsequently, it flowed through the second fracture back into the drilling hole and reached the surface through the inner pipe. Haenel: "We have only tested whether it works. The inner pipe was not insulated because otherwise we would certainly have reached a higher temperature."

In addition to the fact that the method is successful with one drilling hole only, so that it is less expensive than with two drilling holes, the researchers were amazed by one other result. Theoreticians had calculated that to break rock at greater than 3,000 m depth would require a pressure 1,100 times that on the ground, which is approximately 1,100 bar. The weight of the water column in the drilling hole, the hydrostatic pressure, furnished approximately 300 bar. Haenel and his colleagues expected to have to come up with the lacking 800 bars by means of high pressure pumps--a very costly undertaking. They were all the more surprised when there was crackling in the rock at 400 bars. "We have torn open old, so-called healed fissures," explains Haenel, because the earth is never completely homogeneous and because again and again faults and crevasses permeate the rock. Under high pressure these fracture zones may close again ("heal"), but they do remain weak spots.

The Urach project was so successful that water is to be heated in a long-term test with the hot-dry-rock method in the Swabian Alb in the next year. Within the framework of the Franco-German cooperation, scientists from both countries also plan to test in the Upper Rhine Valley additional possibilities towards utilizing energy from hot rock. The Americans, too, after their success in the Valle Grande, want to start additional tests in New Mexico, Idaho and Maryland.

There is one thing the Urach research project could not clarify. Why is the earth below the Swabian Alb so abnormally hot? The matter is clear in the Valle Grande because a hidden magma chamber there heats the environment, a residue of the otherwise extinct volcanism. However, to date nothing like this has been found below Urach, even though there had been volcanoes in the Swabian Alb. The only thing clear is that the largest portion of the geothermal heat is converted nuclear energy. The decay of radioactive elements within the earth's interior releases heat. The other heat portion is as old as the earth itself--it originates in the birth of our planet from a dust and gas cloud more than 4.5 billion years ago. To date, only the earth's crust is cold and solid. Below this, there is enough clean nuclear energy to heat mankind for thousands of years. However, the road there is long--or, better put, deep.

9243
CSO: 3102

FEDERAL REPUBLIC OF GERMANY

PROBLEMS WITH COGENERATION IN DISTRICT HEATING SYSTEMS

Duesseldorf BRENNSTOFF-WAERME-KRAFT in German No 11, Nov 79 pp 419-423

[Article by A. Mareske. "Use of Power-Heat Pairing in Central Thermal Power Plants or Decentralized Block Thermal Power Plants"]

[Text] The use of the power-heat pairing system is to be expanded by means of decentralized small-scale thermal power plants, the so-called BHKW (Block Thermal Power Plants). The multiplicity and complexity of the factors illustrated here will explain the differing views and shows that general statements on BHKW technique are possible only to a limited extent. In addition to primary energy utilization, which is mostly emphasized in this connection, the author covers a series of other evaluation criteria and compares the BHKW technique with centralized thermal power plant technology. The energy-management advantage deriving from the BHKW pairing process can be utilized only if the primary energies used in the public electric power supply systems, that is, coal or nuclear energy, will not be displaced by these plants.

General Remarks

The extension of power-heat pairing is the most effective way to use energy efficiently in our time. In addition to the stepped-up expansion of known thermal power plant technology, investigations are being conducted not only for uncoupling from current generation plants with a large output, for example, nuclear power plants (1) but also for those with a very small output, the so-called BHKW (2-5). The decentralized block thermal power plants--often referred to as a new technology--are to make it possible, with the help of diesel or gas engines from motor vehicle and ship engine series production, to use the power-heat coupling system also for high heat requirement densities in specific small locations (for example, residential blocks).

Where the electrical in-house requirements or the power share (mechanical energy) is very high, for example, water works for pump operation, internal-reciprocating combustion engines or diesel motors or small steam power plants have always been used. Their economy results from the simultaneous generation possibility and the consumption of current and heat.

It is especially important to answer the question as to what conditions must be met today in order to be able to use the so-called BHKW technology beyond the very special framework in an economical manner and what differentiation there is with respect to the conventional-design thermal power plants, for example, with gas or steam turbines.

Definition of Concepts for Designations of Thermal Power Plants

The concept of the HKW (thermal power plant) was used, by way of supplementation of the concept of HW (thermal plant) which generates only heat for building heating and utility water heating, whenever heating heat is generated simultaneously along with current generation in the power plant. The coupled generation of power and heat is referred to in the technical literature as power-heat coupling [pairing]. Nothing has thus been said about the ratio between power and heat and its variability. The recently proposed KHKW (small-scale thermal power plant) (3) or the BHKW (5) represents a special form of the comprehensive concept of thermal power plants. The small-scale thermal power plants mostly are confined to very small electrical and thermal output figures. They do not exceed the hitherto installed capacities of 1 Mw (electrical) and 5 Mw (thermal). They are to be considered only as a form of expanded heating plant technology because the heat supply is the operational management magnitude, not current generation, as in the case of the thermal power plants. The concept of "block thermal power plant" has become accepted for motor generating units. The generating plant mostly consists of several motors for coupled power and heat generation and a small thermal plant so that this term is rather inaccurate. It would be better to use the term KHKW. In our study here we will use the concept of BHKW.

Heat Generation Situation Involving Thermal Power Plants

Long-distance heat supply from centralized thermal power plants presupposes a certain heat density on the part of the consumer amounting to >35 Mw (thermal)/km^2. Furthermore, the generation sites, on account of the high pipeline costs, must not be too far away from the consumer (less than 5 km). Besides, the area supplied must reveal a heat output and work requirement which would economically justify the uncoupling of heat from the current generation process. Today one must furthermore assume that a power plant location close to the consumer can be properly licensed when it comes to using the power-heat pairing processes. Concerning the expansion of the power plant site, the solution of the electrical supply tasks--which the EVU [enterprise covered by electric power decree] is obligated to accomplish on the basis of the concession contract--remains a matter of priority

concern. Because only heat energy can be stored over a short time, the electrical requirement becomes the critical management magnitude for the use of the energy converters in the central thermal power plant. Once these prerequisites exist, then "long-distance heat," as a line-based energy, can be expanded on a stepped-up scale--and this is not something recent. The long-distance heating system of BEWAG [Berlin Power and Light Corporation, East] in Berlin constitutes an example here. In metropolitan areas--primarily in big cities--a large portion of the electrical requirement is being generated at the very center of consumption itself and in this way the necessary power plant output is also used to supply heat. The maximum electrical load in the winter in Berlin is around 30-40% higher than the connected thermal heating load (K-W-K [Power-Heat Coupling]), as we can see in Figure 1. Thus, about 12% of the residential surfaces can be supplied with the help of K-W-K. Using the currently installed thermal power plant capacity, it is possible to reach a figure of 17% in case of further expansion. Other cities, such as Munich, Hamburg, Stuttgart, etc., reveal a similar situation.

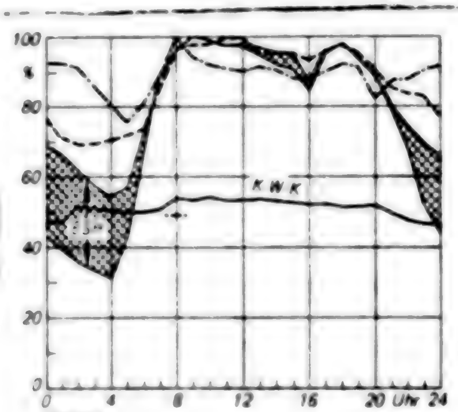


Figure 1. Daily curve for electrical maximum load and coupled heat load (K-W-K).
Key: Uhr--Clock time.

The conditions for decentralized heating heat supply using a BHKW are different. The heat supply task and the fuel to be used--mostly heating oil or natural gas--are given. The heating requirement determines the use of the energy converters. The heat density must be within the same order of magnitude as in a central heat supply task. Because the specific plant costs for decentralized thermal power plants are considerably higher than the long-distance heat share in central thermal power plants, this cost situation limits the heating network investment. The capacity therefore most be guided by the focal-point heat requirement. The heat output capacity of the BHKW is adapted to the local, small heating plants in the residential block. They are presently not yet subjected to the licensing procedure applicable to standard current generating plants. This circumstance plays a decisive role in comparing the emissions. The BHKW operating time is not controlled

by the orientation deriving from the heating requirements for electrical supply [sic]. Besides, the related utilization of mineral oil products is in conflict with energy-policy planning goals which are aimed at guaranteeing current and long-distance heat supply if possible independently of the oil supply.

The problems involved in the correct utilization of the corresponding heating system reside in the differing magnitude and the time differential in the requirements for current and heating heat. In a residential development, the output of current and heat will vary from 1:10 to 1:5, depending on the type of hot-water supply, and the work output requirement likewise is not balanced out in terms of days or weeks. The BHKW for residential developments cannot adapt to this varying requirement especially in terms of current output. It will necessarily achieve a current output which, because of the heating requirement, will be above the residential development's in-house consumption. Besides, the current requirement in terms of time is much more differentiated than the heat requirement. Current swap and current procurement must be worked out with the EVU in order to be able to use the decentralized energy converter, to begin with, and also in an energy-saving manner.

Evaluation Criteria

We must describe and evaluate a series of criteria for these thermal power plants if we want to judge and compare central thermal power plants and decentralized BHKW.

Conditions for Coupled Production

The various types of generating plants involved in the coupled production of current and heat reveal differing forms of performance.

The lifting-cylinder motor reveals a synchronous performance for both output products. Because only its heat loss is being used, we do not get any electrical output losses. The gas turbine, so far used in some thermal power plants, works in exactly the same way. Its efficiency for primary energy conversion into electrical energy of course is not as good as that of diesel or internal-reciprocating combustion engines. The conventional counterpressure plant likewise performs in a similar manner. Its electrical output yield depends not only on the heating requirement, like all other energy converters, but also on the temperature of the hot water. While the gas turbine and steam power plants are in a position to offer any desired heating media temperature from 250 up to 300°C, we can only get a heating lead-in temperature of 80-90°C from the BHKW.

Partial loads however can be better controlled by steam power plant facilities although that can be partly balanced out as a result of the small output when the engine systems are divided up. In order to be able better to adjust to the heat requirements and to minimize the electrical power

losses, the thermal power plant blocks are being predominantly built in the form of tapping-condensation blocks. Motors or gas turbines can only be used in the summer for electric power output if the heat generating plants for heating purposes can be circumvented.

Utilization of Primary Energy

The high degree of primary energy utilization is used as the main argument for the employment of BHKW technology in terms of energy generation. Energy utilization amounting to about 80% has been documented in practical operation for the 600-kw engine solution when these plants are used for heating also (6, 7). These figures can also be attained by thermal power plants predominantly on counterpressure operation. Thermal power plants--such as they are operated by BEWAG with tapping-condensation blocks and counterpressure plants--during the period of heat production attain primary energy utilization coefficients (Rudow HKW example) of 69% or (Steglitz HKW example) 74%, each, after the heat supply system has been connected in. This figure is reduced by 6% on a year-round basis. The reduced utilization coefficients result from the operation of the plants for current generation.

Figure 2 shows not only primary energy utilization for current generation but also the entire utilization volume for current generation and thermal heat as a function of the outside temperature. The curves for thermal power plant technology with tapping-condensation turbines (DT), counter-pressure turbines (DT), and gas turbines with waste heat utilization (GT) are derived from design data and practical operational statistics. They pertain to the full heat supply connection output. For the motor solutions (M), we know the best design point (see the diagram bars) and the partial-load points. Because the BHKW is mostly made up of a multi-motor plant and heating boilers, the curve of the utilization coefficient can presently be determined only by means of computations. The major decline in the area between -15°C and 0°C can be traced back to the small heat output share of the motors. Some of the measurement values from the Heidenheim Plant, with a supercharged natural-gas internal-reciprocating combustion engine of 630 kw, which can provide about 50% of the connected maximum heat load (40% of the installed heat capacity) have been plotted in this diagram (7).

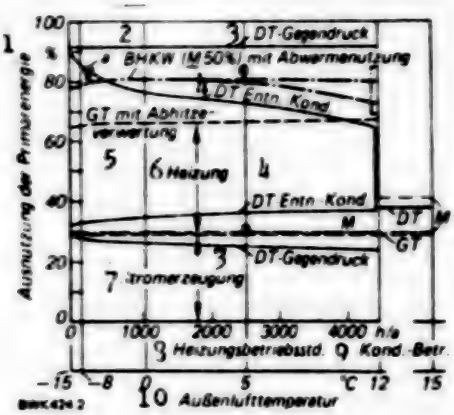


Figure 2. Primary energy utilization in thermal power plant.

Key: 1--Primary energy utilization; 2--BHKW (M [motor] 50%) with waste heat utilization; 3--DT [steam turbine], counterpressure; 4--DT, tapping condensation; 5--GT [gas turbine] with waste heat utilization; 6--Heating; 7--Current generation; 8--Heating operation hours; 9--Condensation operation; 10--Outside air temperature; h/a--Hours per year.

No outside temperature dependence was determined for this central unit. At -5°C, the motor system, at point a, achieves a utilization coefficient of 84% but the remaining heat requirement (25%) must be supplied from the heating boiler (η is assumed to be 0.7 here). As a result of that, there is a reduction in the BHKW utilization coefficient to 80.5%. If we relate these measurement results to the 100-kw motor unit so far used predominantly, then the computed curve is confirmed. Thus we see that the measurement values derived from the motor plant are not decisive when it comes to getting the figure for the BHKW utilization coefficient; instead, the measurement values for the entire BHKW are decisive here. These are the values which must be determined in additional pilot plants.

The motor plants have been optimized in terms of mechanical energy or electrical energy generated, as we can see in Table 1. As the unit output goes up, there is an increase in the electrical energy conversion efficiency while heat utilization declines. The efficiencies for current generation are somewhat higher for diesel motors than for gas motors. Larger motors taken from ship diesel production and operated with heavy oil attained figures of 40% (8) and roughly correspond to 100-Mw steam power plant blocks with reheating. The ratio between current and heat generation is about 1:1.5 for gas operation and 1:1 for diesel operation.

Table 1. Energy Utilization in Power-Heat Coupling Plants (Design Points)

Maschinenleistung, Brennstoff 1		Elektrische Energie (%) 2	Wärme-Energie (%) 3	Energieausnutzung (%) 4
5 **Diesel- oder Gasmotoren**				
100 kW	(Gas) (t_v = 90 °C)	33,7	47,5	81,2
630 kW	(Gas) (t_v = 90 °C)	29	55	84
1,2 – 3,6 MW	(Diesel)	38,3	39,6	78,1
3,3 – 9,9 MW	(Diesel)	40,3	36	76,3
12 MW	(Diesel/ 6 Schweröl)	40	40	80
7 **Dampfturbinen**				
8 Gegendruck				
25 MW	−15 °C (t_v = 92 °C)	19,6	57	76,6
	+12 °C (t_v = 55 °C)	22,6	62	84,6
50 MW	−15 °C (t_v = 110 °C)	29,3	62,7	92
	+12 °C (t_v = 62 °C)	25,5	66,5	92
9 Entnahme-Kondensation				
10 ohne Zü 70 MW	−15 °C (t_v = 110 °C)	28,2	62,7	90,8
	+12 °C (t_v = 62 °C)	32,2	27,8	60
11 mit Zü 135 MW	−15 °C (t_v = 110 °C)	33,7	55,2	88,9
	+12 °C (t_v = 62 °C)	38,3	34,6	72,9
12 **Gasturbinen**				
70 MW	−15 °C (t_v = 110 °C)	29,4	36,6	66
	+12 °C (t_v = 62 °C)	28,5	38,2	66,7
100 MW	−15 °C (t_v = 110 °C)	30,7	37,8	68,5
	+12 °C (t_v = 62 °C)	28,9	41,5	70,4
13 **Dampfmotor** 14				
0,030 bis 0,175 MW		16	58	74

Key: 1--Engine output/fuel; 2--Electrical energy; 3--Heat energy; 4--Energy utilization; 5--Diesel or gas motors; 6--Heavy oil; 7--Steam turbines; 8--Counterpressure; 9--Tapping condensation; 10--Without reheating; 11--With reheating; 12--Gas turbines; 13--Steam engine; 14--To; t_v = water heating lead-in temperature.

Gas turbines reveal a somewhat different tendency with relation to heat utilization; this depends on the turbine input temperature and the necessarily coupled waste gas temperature which is critical for the design of the waste heat boiler. The best utilization coefficients (up to 92%) can be achieved with counterpressure plants, that is to say, we achieve even higher values here than one would expect from a BHKW.

Type of Fuel, Cost Structure, and Reorganization

The use of BHKW makes sense only if not only the current consumed by the customer but also his heating heat can be generated from oil or natural gas. If this is not the case, then the centrally generated current would, in the big coal and nuclear power plant blocks used in the public supply system, be displaced in favor of the BHKW which operates on an oil base in a

decentralized manner. This is bound to have a disadvantageous effect on the current costs of the general consumer.

The energy saving in a facility to be heated, which results from various supply technologies--for example, conventional heating boiler plant or BHKW --can be estimated as follows. If the necessary heat requirement of a certain facility is assumed to be 100%, then the fuel requirement of the BHKW will involve an additional local need of 35-55%, depending on the type of motor and fuel, caused by the necessity of decentralized current generation. If we add to the heating plant's fuel requirement also the separately generated current share for energy adjustment, then we get a saving between 10 and 30%. The saving springs from coupled heat generation because we can assume roughly identical efficiencies for current generation in both cases. In this rough comparison we did not take into consideration the fact that the way the BHKW is run can cause a shift in optimum power plant utilization--something which certainly can lead to additional fuel consumption deriving from separate current generation.

Ruhrgas AG [Inc.] stresses that natural gas and block thermal power plant technology constitute partners (10). BHKW are interesting additional consumers of natural gas. This can result in advantages on several interconnected energy-industry levels. Unfortunately, natural gas is not available in some places, for example, in Berlin, so that this results in a local disadvantage.

Performance Figures

The generating plants reveal differing performance figures. Conventional power plants proved to be economical in the electrical output range of 50-500 Mw with block magnitudes between 20 and 300 Mw. Because of the local heat requirement, BHKW will achieve output figures (electrical) of only 0.5-5 Mw. The motor size will fluctuate between 0.05 Mw and 5 Mw. So far, 100-600-kw motors have been used in BHKW in the FRG. Thermal power plants with gas turbines and steam turbine blocks offer a saleable heat output of 50-500 Mw and BHKW all for only 1-5 Mw. The increasingly less used steam engine (5) takes care of the area between the BHKW and the thermal power plant.

Characteristic Current Value

The characteristic current value is the ratio between simultaneously generated electrical output and heat output. It is a characteristic value for coupled production. With a BHKW one can achieve the same values as with steam blocks or gas turbines. The values pertain only to the motor plant. The trend toward higher characteristic current values for the BHKW goes hand in hand with a declining specific heat requirement connected with current generation. In the designed spread, the BHKW--related to the motor plant--has the same characteristic current values of the tapping-condensation plant. The characteristic current value does not give us

any decisive evaluation criterion or a dividing line within the utilization areas of centralized or decentralized thermal power plants.

Reliable Reserve and Supply Management

Reliable supplies for the two energies represented by current and heating heat, both of which are line-based, depends overwhelmingly on the availability of the generating plants. This is why we can say that, when it comes to dimensioning the reserve of the heating component, the loss of the biggest heat source must be fully covered. That function is performed by all thermal power plants. Only in case of collective heating systems, do we accept a restriction, mostly down to 70%. In case of local regulation, the supply risk is confined to 150 hours per heating period, depending upon the long-term heat curve (3.4% of the peak load time during the period of heating use). In conventional thermal power plants, reserve heat dimensioning is often also subjected to stiffer requirements so that one can get into the same upper shortfall risk range of around 3% because the long-term heat curve is mostly rather flat. In case of plant breakdowns, current generation might possibly be restricted or stopped entirely. But those breakdowns are backed up at any rate by the reserve criteria of the central current supply system within the general supply system and these criteria are guided overwhelmingly by the breakdown probabilities of all power plant blocks.

In the case of the BHKW one might start with the idea that an electrical supply risk need not be taken into consideration because the job of reliably supplying electric power was passed on to the public grid due to the necessary connection with the local electrical distribution network. If this is planned in this fashion, then the current fed into the system can be reimbursed in the current costs only as unsecured output. It then cannot be carried on the balance sheet as output designed to meet requirements. In most cases this is not taken into consideration, nor is the expenditure for the quality of electrical power supply, characterized by the concepts of voltage and frequency.

By way of summary we might say that thermal power plants and BHKW do not differ in terms of the supply risk connected with heating. Major differences emerge in terms of current supply. But this has nothing to do with the differing operator function. This is simply due to the fact that the thermal power plant pipes must meet different supply priorities.

Surface and Space Requirement

The specific surface requirement of the BHKW (0.8 m^2/kw) is higher than that of the presently customary thermal power plants by a factor of 3-4 inspite of the fact that these facilities can be housed in local heating plants (basements or heating-plant buildings). Their decentralized orientation and their small output volume does not bring this differing surface utilization pattern out as clearly. Looking at the specific volume

requirement (BHKW:0.3 m^3/kw), the situation is reversed (fossil thermal power plant: 1.5 m^3/kw). In conventional thermal power plants, centralization and thus also the concentration of industrial structural bodies are becoming a bone of contention in connection with the licensing procedure.

Emissions

Emissions from industrial plants and the immission caused by them are being discussed increasingly in the course of environmental debates. Here even the air guideline TA [technical conditions] are not considered to be strict enough. An evaluation and a comparison of the BHKW with HKW must not omit this criterion. The small output volume here helps in getting licenses for such plants which likewise are not subjected to the BImSchG (Federal Immission Protection Law). A comparison of emissions, related to fuel utilization, can be seen in Figure 3 (9, 10). If we only compare thermal power plants with fuel oil EL/S [light, heavy] or natural gas--the sulfur dioxide content here does not play any role--then the NO_x and CO values predominantly constitute the evaluation criterion. The BHKW reveals the highest values for these emissions. The spread, depending upon the type of plant, is shown by the broken scales.

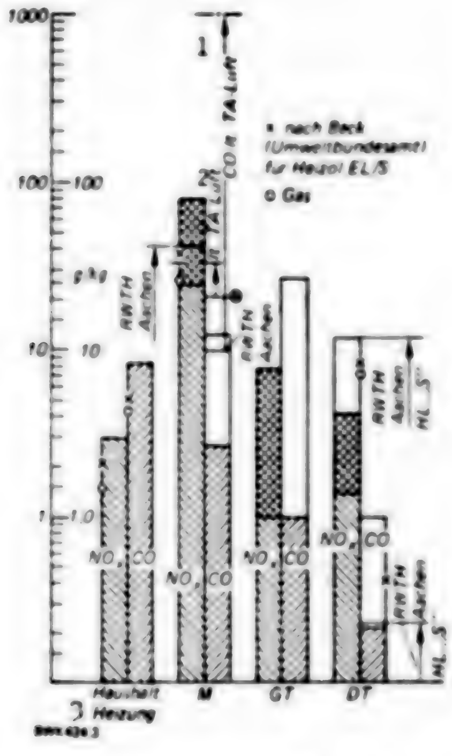


Figure 3. Comparison of emissions related to fuel utilization.

Key: 1--CO according to TA for air; 2--According to TA for air; 3--Household [home] heating; x--According to Beck (Federal Environmental Bureau) for El/s heating oil; HL "S"--Heavy heating oil; -.- Hamburg; ____ West Berlin; --- FRG; M--Diesel motor; GT--Gas turbine; DT--Steam turbine.

The NO_x values are either above the TA for air values or just below. In the case of CO we also get the highest values although the boundary value of TA for air is still higher by almost two powers of ten. The TA for air values were extrapolated from the immissions for the short-term effect.

The emission level likewise differs considerably. While conventional thermal power plants release their waste gases with 80-150 m, a stack height of between 10 m (assumed for the values of the Aachen RWTH) and 20 m has been provided for or has been actually built for BHKW, as in the case of thermal plants. Because of that, the BHKW--depending on the stack height--determine the immission values in the close-in range. Today we do not as yet need any legal base for construction and operating licenses according to the TA for air because, de jure, the BHKW is not on the list of plants that require licenses according to the BImSchG. They are thus not included among plants requiring licenses which, according to Article 22, BImSchG, are to be so operated that harmful environmental effects, which are unavoidable to the state of the art, will remain confined to a minimum (10).

If just as strict criteria are applied for the BHKW as for the power plant systems, then we must expect restrictions and licensing problems for BHKW technology for reasons of emission limitation. This situation can be cleared up and the licensing procedure can be firmed up only with the help of accurate long-term measurements. The stationary ship engines will particularly involve problems here.

Investments, Maintenance, and Economy

All coupled heating processes will become effective as measures aimed at efficient energy utilization and energy savings only if they are economical.

If we compare the investments in conventional thermal power plants in the 20-100-Mw range--related to the installed electric capacity--with those of the BHKW, then, depending upon the capacity, the type of block, design, and environmental safety requirements, they will be in the same order of magnitude. If we relate the investments to the installed heat capacity, then the picture changes. In the thermal power plant, the additional investments, as compared to the current generation plant, are only very small. They fluctuate between 40 and 70 DM/kW (thermal). They are bound to be by 20-50% below those of a thermal power plant because we get economical supply possibilities only with a higher heat output and thus with a more far-flung long-distance heating network. The BHKW, which has a heat output in the kw to 5-Mw range, calls for investment costs of around 200 DM/kw (Heidenheim Indoor Swimming Pool: 23% motor share) up to as much as 390 DM/kw (Ingolstadt: 50% motor share) (10). These figures show the rather steep cost rise in case of an increase in the heat-dependent output resulting from motor exhaust heat in spite of the optimum number of motors--six units--determined in each case. Waste heat utilization from motors does not constitute thermal plant replacement for investment reasons.

If we compare the electrical energy requirement in the household sector with heating a residential development, then we first of all find that the heating requirement will predominate heavily. If we want to meet that requirement with the help of the power-heat coupling system obtained from thermal power plants, then, depending upon the system type, we get a heating-determined surplus current which must simultaneously be taken by the other consumers from the public grid. In the BEWAG supply grid, 60% of the installed capacity currently consists of power-heat coupling plants. Here we come to the limitations of usability and exploitability of thermal power plant blocks. This also applies to BHKW. In Berlin, there might even be an undesired negative effect deriving from the centralized heating systems as a result of the operation of the decentralized heating systems.

In the case of decentralized BHKW, the current yield--which is required to pay off the expensive heating equipment, including current generation--becomes the main economy criterion. This is why the problems of parallel operations with other current generation plants, voltage maintenance, and adjustability assume tremendous significance for the public supply system.

Maintenance, repair, and personnel costs furthermore influence the degree of economy here. The lifetime of a motor is shorter because of the basic differences with respect to the turbomachines. This is why we must assume a thermal power plant lifetime of 25-30 years as against the utilization time of a BHKW of between 10 and 15 years. The operating contract figure offered by the various companies at 2 Pf/kwh [pfennigs per kilowatthour], depending on the duration of utilization (3,500 hours per year) and the lifetime (10 years), is roughly twice as high as compared to the conventional thermal power plants. The personnel costs for the decentralized plant must also necessarily carry more weight in spite of their automatic operation because they call for at least one control round and one inspection daily. On the other hand, personnel can be fully utilized only if there are very many plants in one place. The intervals of inspections by technical personnel from the motor manufacturer are around 1,500 hours at Heidenheim. The utilization time of a motor plant in a BHKW must be more than 3,500 hours per year for reasons of economy. This means, that in case of an annual utilization time deriving from the mathematical heat design requirement of about 1,800 hours per year, only a maximum output share of 50% may be accounted for by the actual power-heat coupling plant. This means that about 80% of the annual heat requirement could be covered from the motor plant whereas the rest would be fresh heat from the boiler plant. In the conventional thermal power plant, the fresh-steam share is only 3-5%.

The market price is decisive for the economy of heat supply. The consumer is currently accustomed to heating costs of 9-12 DM/m^2. With the help of conventional power-heat coupling plants, one can reduce the heating costs by 5-15%. The market price is directly tied in with the fuel price. A BHKW of the design described must, without the evaluation of the current delivery, achieve a value of around 32 (135) to 34 DM/GJ (142 DM/Gcal) corresponding to 24-26 DM/$m^2 \cdot a$ in order to achieve a cost adjustment. Here we assume a fuel price of 14.4 DM/GJ (60 DM/Gcal).

If we now assume the current delivery as the criterion of economy, then we must achieve a reimbursable current price of 27-30 Pf/kwh. Between these two extreme cost figures, there is a large number of combinations for these two coupling products.

Summary

BHKW technology is worthwhile for the consumer only if, in addition to heat supply, there is also a considerable in-house consumption of electrical energy which can be produced through simultaneous coupling production in a more favorable fashion than it could be obtained from the public grid. Long-distance heating is to be preferred for residential developments if a choice has to be made between the conventional power-heat coupling system and BHKW supply. For the high focal-point heat requirement--for which otherwise there would never be a chance of supply from power-heat coupling--BHKW technology may be worthwhile if heat supply is handled anyway on a natural gas or fuel oil base. In addition, the current procured must come from natural gas or oil-fired power plants and the current procurement price must still be above the in-house generation price. Besides, from the attainable current reimbursement, the necessarily heating-conditioned current generation must meet the very much higher additional investments connected with a decentralized thermal power plant. This component is missing in the conventional thermal power plant because the heating-conditioned operation times are insignificant. Only gas-turbine thermal power plants with separate networks are comparable to the BHKW in this respect.

The multiplicity and complexity of the influencing factors illustrated here show us that one cannot make any general statements on BHKW technology. The application possibilities will remain limited. The as yet unresolved problems should be researched in pilot projects. This will also be done partly in Berlin. Nevertheless, priority will have to be given to the expansion of the power-heat coupling system so far from big current generating plants especially in the Berlin metropolitan area. In this way one can most effectively and economically serve the cause of environmental protection and efficient energy utilization.

BIBLIOGRAPHY

1. Bierhoff, R., Krueger, H., Mareske, A., Schaumann, R., Strauss, U., "Heat Delivery from Big Power Plant Blocks for Long-Distance Heat Supply," ELEKTRIZITAETSWIRTSCHAFT, Vol 77, No 6, 1987, pp 193-197.

2. VDI [Association of German Engineers] Report 287, "New Heating Systems --Decentralized Heat-Power Coupling with Combustion Motors," Duesseldorf, VDI Publishing House, 1977.

3. Hein, K., "Small-Scale Thermal Power Plants (KHWK), Comparison with Long-Distance Thermal Plants and Standard Thermal Power Plants," BWK [Fuel-Heat-Power], Vol 27, No 5, 1975, pp 225/227.

4. Hein, K., "Block Thermal Power Plants--A New Possibility for Economical Heat Supply of Residential Developments and Major Individual Facilities," KOMMUNALWIRTSCHAFT, No 2, 1976, p 63.

5. Buch, A., "Energy--Decentralized, Decentralization of Energy Supply by Means of Block Thermal Power Plants," ENERGIE, Vol 30, No 10, 1978, pp 342-345.

6. Pillar, W., and Wolff, U., "The Block Thermal Power Plant--Characteristics and Initial Experiences," ENERGIE, Vol 29, No 11, 1977, pp 376-379.

7. Goericke, R., Hein, K., Pillar, W., Schaefer, H., and Wolff, U., "The Block Thermal Power Plant No 1 in Heidenheim," BWK, Vol 30, No 12, 1978, pp 455-459.

8. Rahn, R., "The Skultune Thermal Diesel Power Plant at Vasteras, Sweden," BKW, Vol 30, No 11, 1978, pp 433-435.

9. Oberlaender, "Reduced Environmental Pollution Due to Gas Turbines," BWK, Vol 31, No 1, 1979, pp 25-29.

10. "Interest Blocks in Connection with Block Thermal Power Plants," ENERGIE, Vol 30, No 10, 1978, BT Special Supplement "Industrial Energy Technology."

5058
CSO:3102

PULSE JET SYSTEM TO BE USED FOR HEATING UNITS

Frankfurt/Main FRANKFURTER ALLGEMEINE in German 5 Dec 79 p 34

[Article by Juerg H. Meyer: "Heat from 'V-1' Jet Unit; Small High-Efficiency Pulse-Jet Furnace."]

[Text] A new type of home-heating furnace, the "Turbopuls furnace," developed by Swedish engineer Boerje Olsson should provide a better utilization of fuel, whether heating oil or gas, than the best traditional furnace systems. In addition, it is remarkably small and has outstanding exhaust characteristics. Although it is only 90 cm high and 35 cm wide, this jet-pulse heat generator can heat apartment houses. It can produce between 5,000 and 50,000 kilocalories per hour. Larger models develop 100,000 to 1 million kilocalories per hour, and, according to the inventor, by installing several burners in the same water tank, any desired amount of heat can be produced, even for industrial purposes. The most astonishing part of this system, at least from a technical point of view, is the burner: It has been directly derived from the jet unit used during World War II to power the German V-1 bombs flying across the Channel and to England.

The engine of the German V-1 "retaliatory weapon" was a so-called "Schmidt-Argus-Rohr," "pulse-jet" in English because it works by intermittent pulsing. At its front end, valve hoods admit air inside a combustion chamber. After fuel has been injected, an electrical spark ignites the mixture to start. The pressure wave thus created closes the valve hoods so that hot combustion gases can escape only at the rear, through the jet pipe.

Under the effect of inertia of the gas masses expelled and through wave phenomena in the jet pipe, a pressure deficiency is created immediately in the combustion chamber; as a result, the valve hoods reopen and new air flows into the combustion chamber into which fuel is injected again. However, the fresh fuel mixture no longer requires outside ignition: Retrogressive pressure waves and hot residual gases densify and ignite it and cause it to deflagrate. Thus, after the initial ignition, a pulse-jet unit continues to operate automatically.

Eighty-seven individual deflagrations occur every second in the burner system of the new type of furnace. It differs from its engine predecessor only in two respects: The outlet of the combustion chamber into the jet pipe is provided with a fixed metal insert which hinders the free passage of the gases and around which they must flow. The additional turbulence of the mixture and of the hot gases created by this deflector appears to enhance the efficiency of the system.

The second important difference compared to the engine is that the jet pipe has now been converted into an exhaust pipe provided with a silencer and which functions as a heat-exchanger since, in this pulsing combustion system, it is not the thrust created by the masses of hot gases expelled which one wishes to use, but only their thermal energy. The hot gases must be given time to yield their heat to the walls of the combustion chamber and of the exhaust system, where it is then picked up by circulating water.

This heat exchange succeeds to a large extent because the combustion chamber as well as the whole exhaust system, including the silencer, are immersed in the water to be heated. How good the heat transfer and the cooling effect thus achieved really are is demonstrated by the fact that the temperature of the hot gases in the combustion chamber is approximately 1500°C, compared with only approximately 100°C at the exhaust pipe outlet. The "immersed-burner furnace," however, does not require any chimney; an exhaust pipe with an inner diameter of 2.5 to 3 cm is enough.

The "Turbopols"--the name of the new heating system--seems to warrant high expectations, although it has not yet been tried on a large scale. Nevertheless, the Swedish National Institute for Materials Testing has acknowledged that in this system "...combustion took place correctly, with a relatively high combustion efficiency and without difficulties, in spite of relatively large variations with respect to combustion air-flow and oil-flow."

Whether, as the inventor claims, the pulse-jet system will make possible "an average fuel saving of over 30 percent" compared to conventional heating methods, remains to be confirmed by actual practice. The device, which was demonstrated recently in Frankfurt/Main, appears to be still at the prototype stage. Nevertheless, it was impressive by its small size and its quiet operation. A comparison of its level of noise with that of the compressor of a large household refrigerator should approach actual conditions.

9294
CSO: 3102

FEDERAL REPUBLIC OF GERMANY

IMPROVED ELECTROLYSIS PROCESS FOR HYDROGEN PRODUCTION

Frankfurt/Main FRANKFURTER ALLGEMEINE in German 5 Dec 79 p 33

[Article by K.R.: "Hydrogen from Superheated Steam Electrolysis; Zirconium Oxide Ceramic as 'Solic Electrolyte'/New Developments at Dornier System."]

[Text] Hydrogen has the best chances of becoming in the long run the main primary energy source of mankind; the cheapest way to produce it is through the decomposition of water by an electric current. However, since water decomposition requires a relatively large amount of power, attempts to reduce power requirements are being made at various locations. As we have already reported here (FAZ dated 6 October), Prof E. Justi, Braunschweig, advocates the development of solar power stations in areas having a lot of sunshine in order to use free solar radiation as primary energy. In modern facilities, the decomposition of water is achieved with an efficiency of 60 to 70 percent. Since coal power stations produce electricity with an efficiency of at most 38 percent, the overall efficiency of hydrogen production does not exceed 25 to 26 percent.

Since the amount of power required for the decomposition of water decreases as the temperature of the water increases, due to physical factors, Dornier System GmbH of Friedrichshafen wants to develop a technique for the electrolytic decomposition of superheated steam at 900-1000°C. Laboratory experiments have already confirmed in principle the feasibility of the process and, according to Dornier's experts, an overall efficiency of over 40 percent with respect to primary energy consumption can be expected. For an electrolysis unit (module) with a steam temperature of 900°C and a pressure of 20 bar (average cell voltage of 1.3 volts, current intensity of 0.4 ampere per square centimeter), Dornier claims to achieve a conversion efficiency of 41-45 percent with respect to primary energy consumption--depending on power density. Compared with "coal-power" electrolysis, this would represent a very interesting improvement.

Electrolysis of superheated steam requires a technique entirely different from the usual electrolytic processes. Instead of a liquid electrolyte (usually a 25 percent or so solution of potash lye in water of high purity), it uses a hollow cylinder of ceramic with extremely fine pores,

made of stabilized zirconium oxide to which a small amount of yttrium oxide has been added. This "solid electrolyte" has the advantage that it remains chemically unaltered and that only gases (steam, hydrogen and oxygen) have to be circulated during electrolysis. In addition, there are no by-products detrimental to the environment. The electrodes required to supply the current no longer have to be made of precious metals. The anode (+) is wrapped around the hollow electrolyte cylinder; the cathode (-) lines its inside. The decomposition of the steam circulating through the hollow cylinder takes place on the cathode side and the concentration of hydrogen produced in the steam current increases, while oxygen ions migrate through the zirconium oxide ceramic to the outside and are then discharged in the form of neutral oxygen gas. The zirconium oxide membrane, therefore, achieves not only the decomposition of water but also the separation of the two gases produced.

Individual electrolytic cells a few centimeters long, 1.5 centimeters in diameter, with walls 1.0 millimeter thick--have to be placed in series to form larger units, which are then connected in parallel to form entire units (modules). To produce superheated steam for the electrolysis, water is first vaporized using the heat of both gases produced, hydrogen and oxygen; it is then superheated by an appropriate high-temperature heat source, and electrolyzed.

The critical question in this process lies in the overall energy balance. A cheap source of high-temperature waste heat is required; this may be provided by some technical processes, or else it has to be produced directly by a high-temperature reactor or by one of the solar-tower power stations which are now being developed. During periods of low power demand, it might be possible to use hot helium gas from a high-temperature reactor to produce superheated steam for the electrolysis according to the Dornier process. This would also be important as it would make it possible to store electrical power in the form of hydrogen, which would mean a rational exploitation of the reactor and, consequently, an energy saving.

Fundamental research on the utilization of solid electrolytes for metallurgical purposes and to save energy--research, which, in principle, has a high development potential--had already been made by H. Sundermann at the Karlsruhe Nuclear Research Center in the late 1960's; unfortunately, this research was discontinued.

We would also like to mention here that the high expections which had been placed for a time on the thermochemical production of hydrogen, as proposed by Marchetti, have not been realized because of the high amount of heat required. At Ispra, where Marchetti had developed it, research on this process has been discontinued.

9294
CSO: 3102

FEDERAL REPUBLIC OF GERMANY

POSSIBILITIES, PROBLEMS WITH PLASTICS IN AUTO MANUFACTURE

Wuerzburg AUTOMOBIL-INDUSTRIE in German No 4, 1979 pp 79-84

/Article by Hermann Hablitzel/

/Text/ Threatening bottlenecks in the energy supply and the worldwide shortage of raw materials are currently being often used as alibis, contrary to economic contingencies, to give preference to light construction of vehicles. Industry, legislators, and consumers are urged to regard weight reductions for saving fuel in the operation of the vehicle as an absolute necessity. Previously, materials were usually selected according to the principles of optimizing function, costs, and production. But this process has been expanded by additional factors. Energy savings in vehicle operation is an important, but not the only, point. Within the overall scope of these considerations, the utilization of plastic parts forms an important part, which pertains only partly to weight saving.

More important than weight savings resulting from the use of expensive light materials, now is an energy-conscious driving style, supplemented by appropriate transmission stages, c_w-value reducing spoilers, and the like. The Federal Ministry for Traffic points out that a sensible driving style alone could save 1.3 billion liters fuel per year in the FRG.

The seriousness, energy, and creativity which the automobile industry is expending on developments concerning the problem of weight reduction, and the limiting constraints and requirements, will be explained in the following discussion, using the application of plastics as an example.

It will here appear that the utilization of plastics did not yield a reduction of vehicle weight, but did represent the best opportunity for solving a problem while keeping the

weight as low as possible. It will also appear that plastics are a future-oriented material, with a multiplicity of additional good properties. Plastics will therefore not be used solely to reduce the weight of vehicles.

The Selection of Materials and the Clamor for Weight Reduction

A constant improvement and practical application of materials development greatly influences technical progress in the overall area of vehicle construction. Materials are selected according to the self-regulating principle of optimizing function, cost, and production.

Especially in passenger car construction, comfort must be included among the functions of the vehicle. This point also comes to the fore in the analytical value considerations which distinguish utility and prestige functions. It will turn out that increasing demands for comfort have entailed increased weight. The same holds for increasing technical requirements and legal directives.

Between 1965 and 1974, the weight of the American Motors compact car rose by 12 percent, that is by 140 kg. Only 12 kg of this are product novelties. The remaining 128 kg were necessitated by new laws. During the same time, fuel consumption rose by 25 percent, because of the higher weight and because of the exhaust purification devices.

When considering economic perspectives, the selection of materials is highly significant, since 53 percent of the manufacturing costs of a vehicle are material costs (Figure 1). Because so much energy is required to produce raw materials and to refine them into semifinished and finished products, measures for selecting energy-saving methods to produce and manufacture materials will play a special role in the future.

In 1965, the Research Department for Energy Economy of Karlsruhe Technical University published an energy analysis for the manufacture of medium-class passenger cars. For simplicity and clarity, the demand for heat energy and electrical energy for the semifinished goods stage and for the finished parts stage was referred to kilowatt hours. The total energy demand was determined at 11,050 kWh per car. This energy demand approximately corresponds to 1½ times the annual demand of a fully electrified private residence of average size. Figure 2 shows a comparison of the energy consumption for semifinished goods and for finished goods. It here appears that 80 percent of the 11,050 kWh per car is needed to produce semifinished goods and 20 percent is needed to manufacture the finished car. It is clear that energy savings in the production of semifinished goods can yield greater gains, e.g. by shortening the

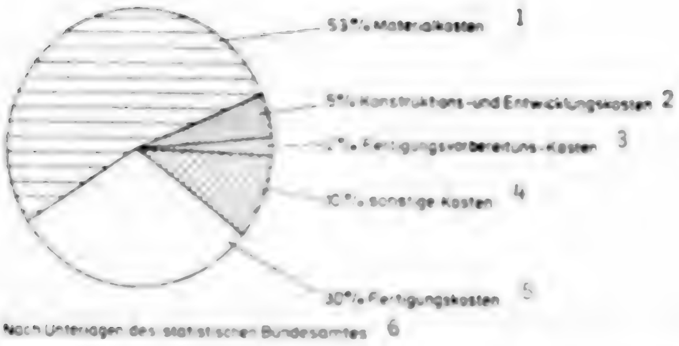


Figure 1: Breakdown of cost factors in the production of motor vehicles

1. 53% material costs
2. 5% design and development costs
3. 2% costs involving preparation for production
4. 10% other costs
5. 30% production costs
6. According to documentation from the Federal Office of Statistics

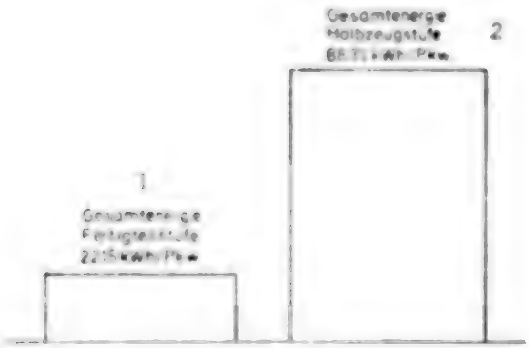


Figure 2: Specific energy consumption during the different phases of the production of a medium-sized auto

1. Total energy, finished part stage, 2215 kWh/car
2. Total energy, semifinished goods stage, 8835 kWh/car

production process from raw materials to semifinished goods. The frequently repeated heating and cooling phases should be reduced. It might be imagined that the production of resin mats for polyester production occurs directly before the processing machine. Several problems must still be solved here.

Finished parts of unlimited lifetime are unimaginable. Consequently, possibilities for recycling should be used in principle for the materials that are used in mass production. For future developments, it is important to consider not only a functional optimization of construction parts but also the principles of long-term preservation of components, their suitability for recycling, as well as the application of energy-saving methods for producing materials and for final production. Furthermore, waste removal is also significant.

All this must be added to the energy saving from weight reduction when the vehicle is operated.

To summarize once again: When optimizing construction components, the following points must be increasingly considered in the future, all of which are to be regarded under the premise of conserving energy and raw materials:

- Light construction with full utilization of materials properties

- Improvements of long-term behavior (reliability in use and preservation of value)

- Energy-saving production of raw materials

- Energy-saving methods for final production

- Energy saving during operation

- Recycling

- Reduction of waste problems

The problem of saving energy and protecting raw material reserves cannot be mastered solely by the engineers of vehicle development. They must be shared by government and by the overall economy.

If all interrelationships are considered, it might well be possible that a very light material, which requires much energy to become a finished part, will not yield the highest energy saving within a prescribed time interval and with a prescribed number of kilometers. This is illustrated in Table 1, which compares an aluminum engine hood and the two-part GF-UP engine hood.

Here too, much study is still necessary, until adequate information is available for the engineers, so as to analyze and compare materials more precisely.

Table 1: Total energy consumption for fabricating an engine hood of average size and for operating the vehicle during its lifetime

Design	Weight kg	Energy for Production 10^6 kj	Energy for Operation 10^6 kj	Total Energy 10^6 kj	Saving Compared to Steel
Steel	34	2,200	8,880	11,090	-
Aluminum	17	4,100	4,380	8,566	23%
GF-UP two-part	22	2,000	5,565	7,550	32%
GF-UP one-part	16	1,450	4,026	5,460	49%

Where Does the Money Go?

At various points there certainly are opportunities and examples for producing lighter components, despite the utilization of more expensive materials, which become equal or more favorable in cost. When deciding for a material, the lighter material must in the future be preferred if costs are the same.

It could also be said that the customer must pay more for his vehicle if he is going to use less fuel. Dr. Behles has developed a formula for this. This formula shows that, when the costs are meaningfully passed on to the customer, a surcharge of about 2.00 DM/kg weight saving could be demanded, if the extra expense is amortized after 45,000 km.

This method cannot be introduced quite so simply. It requires the agreement of marketing. Reeducation of the buyer is required, since he must be convinced that he will gain an advantage with this purchase. The method is not quite so strange, if one considers the extent to which diesel engine cars are currently being purchased. With this mode of procedure, light construction could be introduced worldwide, independent of laws without a necessity of fulfillment.

For the time being it appears safer to rely on legal regulations and to permit extra costs only in the context that the legislator burdens vehicles with extra consumption. In America there are numerous studies on this point, which first start from the fact that only those extra costs will be paid which are caused by legal penalties. But, as already mentioned, one can also figure that savings will also be accounted elsewhere and that the saving of fuel will be taken into account.

The calculations are based on a driving distance of 10,000 miles. The legal requirement of 34 mpg for a 2,000-pound (907 kg) vehicle can be met with permissible extra costs of 0.83 dollars per pound (3 66 DM/kg).

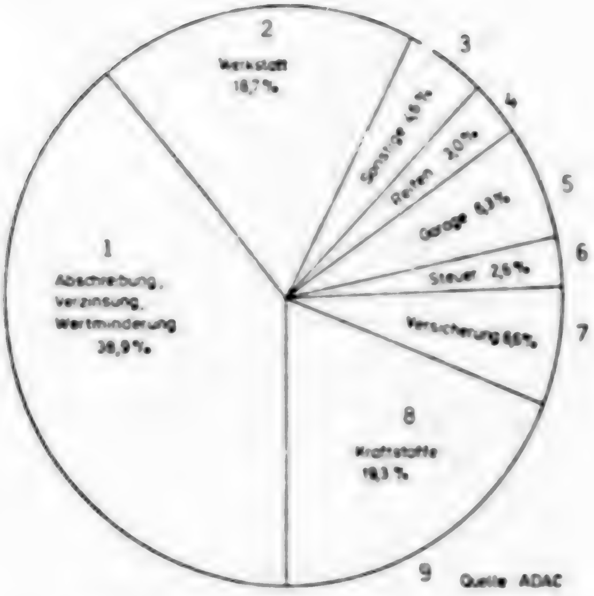


Figure 3: Costs of operating a motor vehicle

1. Depreciation, interest, loss of value 38.9%; 2. Repair 18.7%; 3. Other 4.6%; 4. Tires 3.0%; 5. Garage 6.3%; 6. Taxes 2.6%; 7. Insurance 6.6%; 8. Fuels 19.3%; 9. Source: ADAC

In this way, the buyer would pay for the government requirement in the purchase price, with extra charges for weight saving. Furthermore, because of this "advance", he would finance in advance the government costs for energy saving. He would reclaim this advance after 10,000 miles, and he would then have a gasoline savings advantage for further use.

But development engineers must also consider other points. Figure 3 shows that nearly 40% of motor vehicle costs are paid for depreciation, interest, and value reduction. This value will increase, where fuel costs, which amount to 20%, decrease. Another comparison (Figure 4) shows that repair costs have risen more steeply than basic living costs. By contrast, replacement part costs have risen significantly less steeply. But with expensive, light add-on parts these costs would likewise rise. These parts therefore should absolutely have a longer life expectancy. As far as corrosion is concerned, a longer life expectancy is certainly expected with plastic parts.

In selecting materials, the development engineer places great stress on functional improvement. The customer, however, stresses improvement of comfort and prestige value. Neither one of them is primarily concerned about weight saving. For the customer, the example of the aluminum

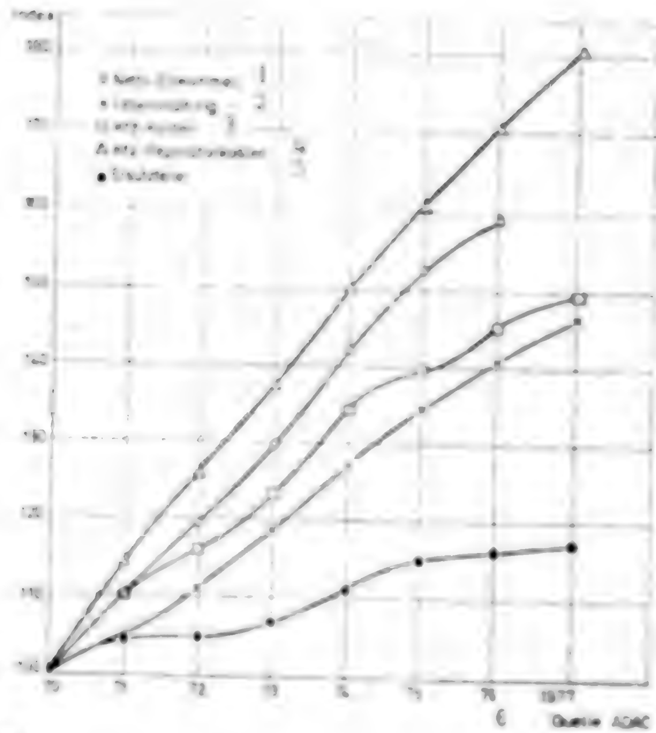


Figure 4: Costs

1. Net income; 2. Basic living costs; 3. Car costs; 4. Car Repair Costs; 5. Replacement parts; 6. Source: ADAC

wheel is useful. A steel wheel costs 45.53 DM as a replacement part. An aluminum wheel costs 206.48 DM, with a 1.2 kg weight saving.

How Compatible Are Manufacturing Optimization and Light Construction?

Manufacturing optimization does not merely mean improvement of assembly units and devices and of automation. New aims are also present, such as

- humanization of the work place
- maintenance of production flexibility
- reducing delivery times.

To the first point belong things like the avoidance of overhead work, assistance in assembling heavy parts, mounting of subassemblies on perspicuous mounting equipment next to the moving belt, and the like.

The remaining two points also have to do with subassemblies and systems of subassemblies. Figure 5 shows the growth of model variety in the

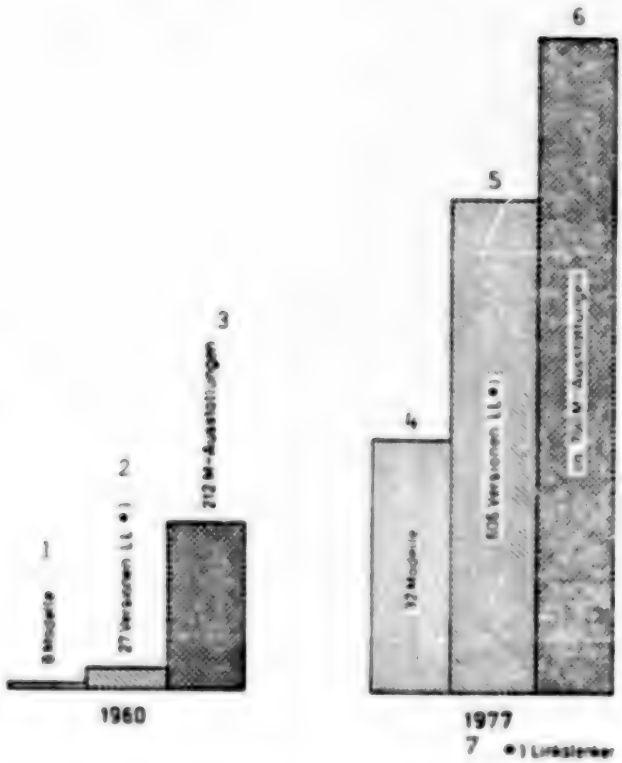


Figure 5: Comparison of the VW type range

1. 8 models; 2. 27 versions LL *); 3. 212 M-equipment;
4. 32 models; 5. 606 versions LL *); 6. About 700 M-equipment;
7. *) Left steering

passenger car sector of the VW (Volkswagen) Inc. To control this variety, to fabricate, purchase, and store the parts, to prepare them for production, requires higher and higher expenditures. A systematic ordering and utilization of equivalent parts is an aid that is urgently needed here.

But in most case, units which cover a wider spectrum of models imply an increase of weight. The same holds for the unification of subassembly systems. In this sector, we need light construction urgently, in order to stop the weight increase.

What Is Actual Practice Like?

It is certainly important to be able to satisfy future requirements and to take timely precautions, in case reasons other than legal requirements should make it necessary to build still lighter cars.

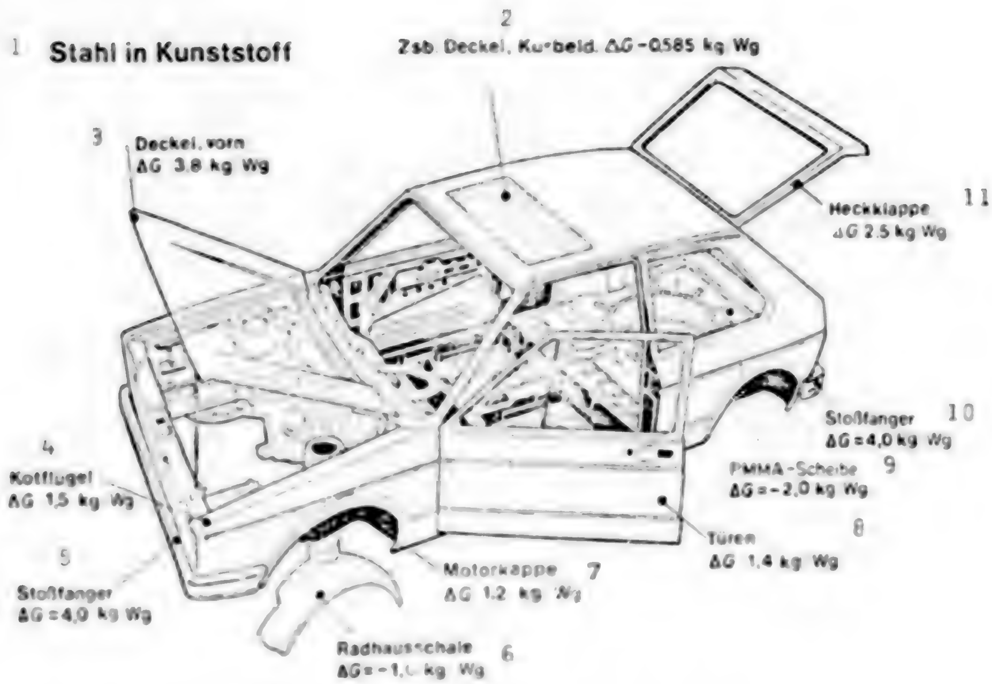


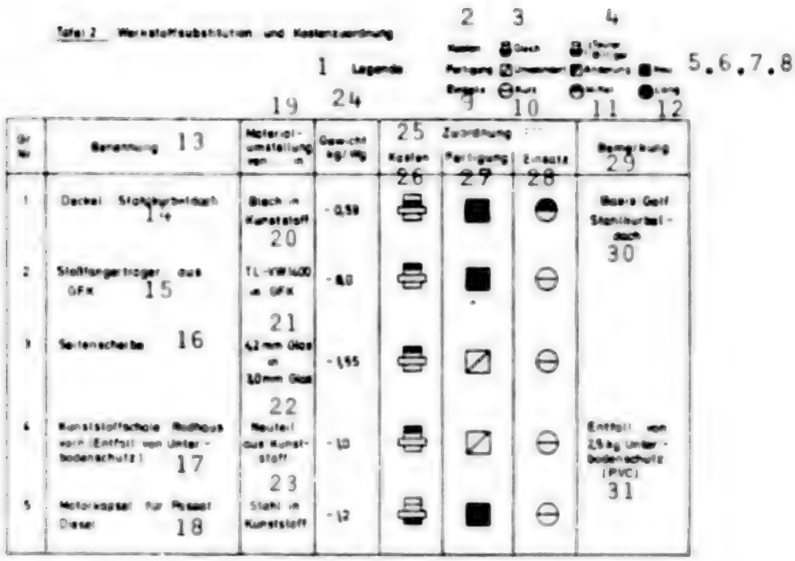
Figure 6: Possibilities for future use of plastics

1. Steel to plastic; 2. Sun roof, cranked; 3. Hood, front;
4. Fender; 5. Bumper; 6. Wheel well; 7. Motor cap; 8. Doors;
9. PMMA-plate; 10. Bumper; 11. Rear Lid

Figure 6 shows several possibilities for the future application of plastics. Their implementability can be monitored and categorized by priorities in a fashion similar to that shown in Table 2. Costs must here be evaluated (DM/kg) just like the development risk. The effect on production is also a factor here. Difficult developments with production changes generally require about four years.

What Good Has the Use of Plastics Achieved By Now?

When one speaks about the use of plastics in vehicles, the interior finish is especially important. Just two-thirds of all high polymers used in vehicles substitute materials such as felt, damping materials, textiles, and soft trim. (Figure 7). Only one-third replaces metals. About 45 kg high polymers were used in the VW Golf (Rabbit) with standard equipment. Three types of plastics have at this time proven dominant in the application of plastics to automobile construction. PVC, PUR (polyurethane), and ABS represent nearly 75 percent, while PP (polypropylene) is increasing



Tafel 2 Werkstoffsubstitution und Kostenzuordnung

Legende: Kosten: Gleich, Teurer/Billiger; Fertigung: Unverändert, Änderung, Neu; Einsatz: Kurz, Mittel, Lang

Lfd. Nr.	Benennung	Materialumstellung von - in	Gewicht kg/Kfz	Zuordnung: Kosten	Zuordnung: Fertigung	Zuordnung: Einsatz	Bemerkung
1	Deckel Stahlkurbeldach	Blech in Kunststoff	-0,58				Basis Golf Stahlkurbeldach
2	Stoßfängerträger aus GFK	TL-VW1400 in GFK	-8,0				
3	Seitenscheibe	4,2 mm Glas in 3,0 mm Glas	-1,55				
4	Kunststoffschale Radhaus vorn (Entfall von Unterbodenschutz)	Neuteil aus Kunststoff	-1,0				Entfall von 2,5 kg Unterbodenschutz (PVC)
5	Motorkapsel für Passat Diesel	Stahl in Kunststoff	-1,2				

Table 2: Material substitution and cost assignment

1. Legend; 2. Costs; 3. Equal; 4. More expensive, cheaper; 5. Production; 6. Unchanged; 7. Change; 8. New; 9. Utilization; 10. Short; 11. Medium; 12. Long; 13. Designation; 14. Roof, steel crank roof; 15. Bumper support of GFK; 16. Windowpane; 17. Plastic wheel well front (obviates underbody protection); 18. Motor capsule for Passat diesel; 19. Material change from...to; 20. Steel plate into plastic; 21. 4.2 mm glass into 3.0 mm glass; 22. New part of plastic; 23. Steel to plastic; 24. Weight kg/car; 25. Assignment; 26. Costs; 27. Production; 28. Utilization; 29. Remark; 30. Basis: Golf cranked sun roof; 31. Omission of 2.5 kg underbody protection (PVC)

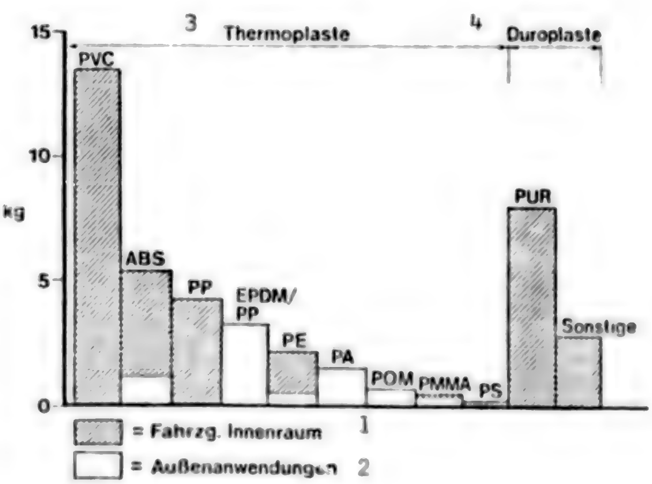


Figure 7: Plastics in the VW Golf (Rabbit)

1. Vehicle interior
2. Outside applications
3. Thermoplastic
4. Duroplastic

its proportion. With these applications, surely no great weight savings can be achieved. On the contrary, safety requirements and urgently needed improvements of convenience have made the cars heavier with the increasing use of plastics. But it must be stated that the use of plastics can achieve the fixed objectives with the lowest possible weight.

If one compares the dashboard of the VW Jeep with the currently used dashboard of the VW Jetta, the difference in convenience and information is enormous. This was achieved with the lowest weight by using plastic on the dashboard body, at the heating and ventilation, in the instrument area, at the steering wheel, at the instrument panel, and in many other details.

Figure 10 shows the air conditioning/heating/ventilating system of the Golf with a large number of plastic components. Producing this unit of sheet metal would be nearly impossible. Even the very simple ventilation of the VW Type 2 encountered difficulties in sealing the box that was welded together of individual sheet metal parts, difficulties which persisted throughout the entire series.

Functional improvements from the use of plastics must also be paid for by additional weight The bumpers with a plastic sheath, weigh 4.9 kg more than the previous chrome-plated bumpers. This was an urgently needed funtional improvement, which could be implemented with the introduction of the modified polypropylene EPDM. After it was introduced by VW, it likewise became the state of the art with many automobile manufacturers, in the same or in similar fashion.

A better example is the development of the plastic fuel tank for the Passat (Dasher) variant. This development was begun in order to achieve a technical advance. The main point was better space utilization than was possible with the two-part metal tank, with consequent increase of capacity. Furthermore, there previously were rust and tightness problems.

The plastic fuel tank of the Passat has a net weight of 3.7 kg and a capacity that is 5 l larger than the metal tank. Since its use in 1973, nearly one million tanks have been fabricated.

The weight savings was not precisely foreseeable, since the required wall thickness had to be determined in lengthy experiments. This development became possible only through highly specific teamwork between the automobile manufacturer and the raw material and machine manufacturers. It was not only important to develop and test the plastic tank, but also to prepare production and to guarantee a constant production quality.

As shown here, the plastic developments did not occur primarily in order to save weight, but under the traditional perspectives of improving materials and function, reducing costs, and optimizing production. The following possibilities existed:

- Only plastics make any sense for solving the problem.
- Plastics are more economical.
- A more expensive material is used because the costs are compensated

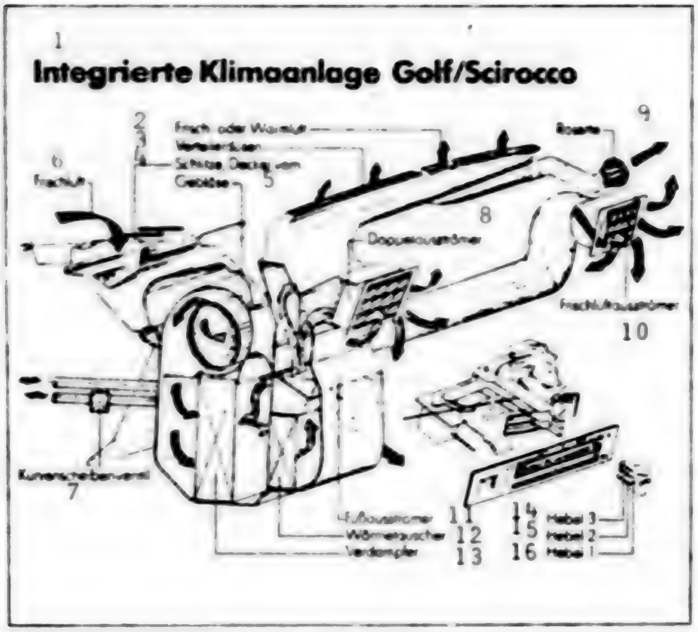


Figure 10: Integrated air-conditioning system in the Golf/Scirocco

1. Integrated air-conditioning system Golf/Scirocco; 2. Fresh or warm air; 3. Distributor nozzles; 4. Slots, cover of; 5. Blower; 6. Fresh air; 7. Curve sliding valve; 8. Double outflow; 9. Rosette; 10. Fresh air outlet; 11. Foot outlet; 12. Heat exchanger; 13. Vaporizer; 14. Lever 3; 15. Lever 2; 16. Lever 1

Since light construction is being emphasized more, and since the premises that have been listed are becoming more telling and therefore need to be even more seriously considered, the use of plastics needs to be reconsidered once again.

What Is the Future of Plastics?

Plastics in Comparison to Other Light-Construction Materials

The following considerations refer mainly to the body area, since the use of plastics in the engine and transmission area is very difficult because of heat and strength stresses and up to now has been successful only in small quantities. Similar conditions prevail in the chassis area.

If one wishes to save weight in the body area, one must approach the conversion from metal to plastic. Duroplastics here have a greater chance than thermoplastics. The next comparisons should concern reinforced polyester, without necessarily completely excluding thermoplastics.

In order to estimate the chances, the steel sheet used in body construction must first be compared with aluminum and polyester. Table 3 shows a comparison of surface weight for the same rigidity. An old basic rule states that aluminum must be about 20 percent thicker than steel in order to achieve the same rigidity, and glass-fiber reinforced polyester must be at least three times as thick as steel in order likewise to achieve the same rigidity. A precise follow-up calculation yields the

Table 3: Weight comparison of different materials (for the same rigidity)

Material	Thickness (mm)	Volume Density γ	Surface Density kg/m^2
Steel plate	0.9	7.8	7.02
Glass fiber reinforced polyester	2.5	1.7	4.25
Aluminum plate	1.3	2.7	3.51

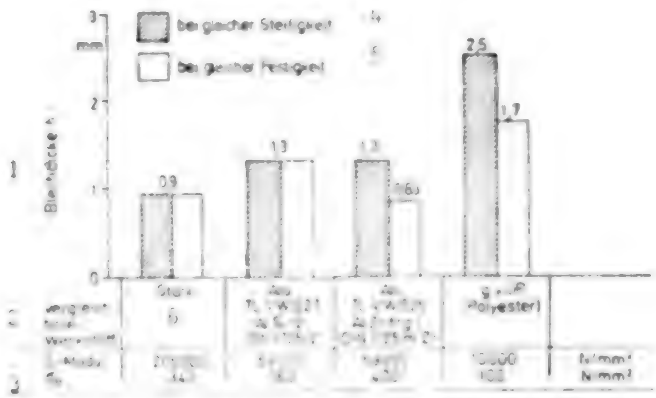


Figure 13: Thickness comparison for a flexible shaft

1. Plate thickness h; 2. Comparable material; 3. Elastic modulus;
4. For the same rigidity; 5. For the same strength; 6. Steel

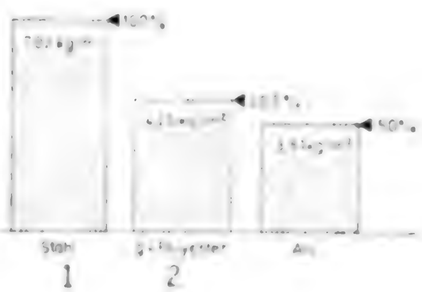


Figure 14: Weight comparison

1. Steel; 2. Glass fiber reinforced polyester

values shown in Figure 13. It here appears that, for the same strength, the thickness of polyester as compared to steel need only be doubled. A better aluminum quality can make do with nearly the same thickness as steel. However, it needs to be considered here that large-area polyester parts can today scarcely be fabricated with a thickness less than 2.5 mm, and the processes need still be developed. With aluminum, because of follow-up work e.g. in polishing the pressed parts, the thickness must be increased in any case, so that the material will not be ground through too fast.

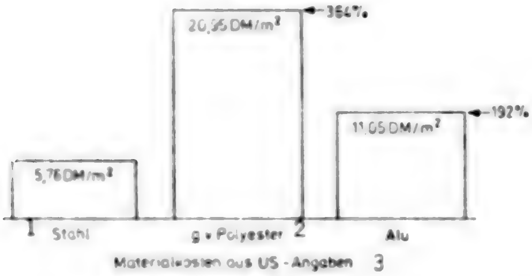


Figure 15: Comparison of costs for metals of the same rigidity

1. Steel; 2. glass fiber reinforced polyester; 3. Material costs from U.S. data.

Let us first stick with these values. If the weights are then compared, aluminum yields a weight saving of 50 percent and polyester a weight saving of 40 percent as compared to steel (Figure 14). American studies indicate that aluminum can also achieve a 50 percent saving in the castings area of the engine. This should count as a basic rule for future considerations, although very many basic studies, comparisons, and juxtapositions need still to be performed.

The studies cited here are based on American documentation. It appears that about 5.76 DM must be paid for 1 m^2 steel plate. This must be compared with about 21.00 DM/m^2 for polyester and about 11.00 DM/m^2 for aluminum. If steel plate is again set at 100 percent, the polyester price is 364 percent and the aluminum price 192 percent (Figure 15). For economy, it must be considered that aluminum must in every case be processed similarly as steel plate, i.e. the number of parts and the number of connections of individual parts to make a total unit will scarcely change. In addition, it should be noted that the connection work will be somewhat more difficult in the welding area (spot welding and protective gas welding), so that the extra price for the material remains fully effective. Different circumstances prevail with polyester.

There new methods are available, which reduce the number of individual parts, and which promise entirely new developmental perspectives. Processing also opens up new perspectives. The difficulty here is the development risk and the risk in constructing entirely new production methods.

One can well imagine that the objective of a plastic body will be reached step-by-step. First one will concentrate on hang-on parts, such as lids, doors, fenders, etc. Then one will also turn to the body proper.

(Continuation in AUTOMOBIL-INDUSTRIE 1/80)

Summary: Can Plastics Save Weight in Motor Vehicles?

The utilization of plastics in motor vehicles was, at least so far, less governed by savings of weight, but by criteria such as the optimization of functions, costs and production. These are aspects which will in the future be as important as now, but more emphasis will probably be placed on weight as a decisive criterion. Savings of energy - as a measure of energy conservation - can be enacted with a more fuel-consumption-conscious driving, better stepped gearings, spoilers for reducing the aerodynamic resistance etc. Energy can, however, be saved during the conversion of raw material into semifinished products - for instance, if the heating and cooling phases can be curtailed. More attention will in the future also have to be paid to the possible mechanical life of components, and not only to their functional optimization. Of importance is also a possible recycling and the application of energy saving production and processing methods.

8348
CSO: 3102

FEDERAL REPUBLIC OF GERMANY

AREAS FOR FURTHER DEVELOPMENT OF VEHICULAR DIESELS

Wuerzburg AUTOMOBIL-INDUSTRIE in German No 4, 1979 pp 31-37

/Report on a Seminar at Esslingen Technical Academy by Ruediger Frank, Rolf Greiner, Helmut Tschoeke/

/Text/ The Esslingen Technical Academy as an Institute of Contact Study at Stuttgart University and at the Esslingen Engineering School is particularly concerned with the education of engineers. In October 1980, a second course on diesel engine technology will take place there. The paper below reports on the first course of this type at Esslingen Technical Academy. Under the scientific guidance of Prof. Dr. Ing. U. Essers, Institute for Interral Combustion Engines and Motor Vehicles (IVK), Stuttgart University, various experts of industry gave a survey of the present status of diesel engine technology and on focal points of future development. About 180 persons participated from industry, government agencies, research, and teaching. The participants were additionally offered two inspections at Bosch Company and at the IVK, to supplement the lectures and to clarify the subject.

Noise Problems

In vehicles which are propelled by a diesel engine, engine noises dominate under most operating conditions. This is particularly true for utility vehicles. Two lectures address themselves to research on the causes and measures for reduction of noises that are specific to diesel engines.

Dipl. Ing. Gross (KHD) (Kloeckner, Humboldt, Deutz) divided the total noise emission of the engine into components which result from the direct generation of air sound, e.g. noises which result at the off-gas exhaust and the air intake as well as noises caused by the cooling blowers, and into portions which are radiated as indirect air sound.

The radiation of indirect air sound is preceded by an excitation of engine parts or of the entire engine structure through the pressure in the combustion chamber (combustion excitation) and e.g. by inertial or impact forces or other periodic processes (mechanical excitation). The engine surface is excited to vibrations by the conduction of body sound, and therefore radiates air sound.

For the effective reduction of the overall noise level, countermeasures against all component noises must be found and applied.

With vehicular diesel engines, combustion excitation represents the main form of excitation. The change of the piston arrangement in the ignition dead center area is also influenced through the pressure in the combustion chamber. The behavior of the pressure in the cylinder and consequently the combustion process is therefore highly significant.

The pressure excitation spectrum is influenced by the pressure rise at the beginning of ignition, in the frequency range II between 0.3 and 3 kHz, which determines the sound level. (Figure 1.) The steeper the pressure rise, the lower is the decay rate of the nearly linear spectrum drop in this frequency band. For example, with very hard combustion, the decay rate is about 20 dB/decade (decade = 10 times the frequency). In this case, combustion processes with a divided combustion chamber or turbocharging engines have a decay rate of about 40 dB/decade. The usual direct injection engines have a decay rate of about 30 dB/decade, and, for comparison, combustion in a carburetor engine has about 50 dB/decade. The low frequency region I (compare Figure 1) is primarily stamped by the maximum ignition pressure and by the completeness of the combustion pressure process. The rise in the higher frequency range III is essentially based on superposed pressure fluctuations in the region of maximum ignition pressure. Figure 2 shows the effect of the combustion process on the pressure excitation spectrum. When combustion excitations dominate, in principle all measures are acoustically effective, which soften and smoothen the pressure rise at the beginning of ignition, i.e. which reduce the ignition delay. This is also one of the reasons why turbocharging has a noise-reducing effect on combustion noises.

During the further course of the paper, it was emphasized that body sound in force-carrying engine parts can be reduced by increasing the impedance of the component structure and by displacing the natural frequencies into higher frequency ranges (this requires a design that is stiff with respect to bending) with smaller amplitudes. Sound radiation from velocity-excited parts of the engine surface such as e.g. the oil pan, the valve and control cover, can be effectively reduced by the insertion of elastic elements. Displacing the mounting points of these covers into areas of greater stiffness results in reduced excitation of

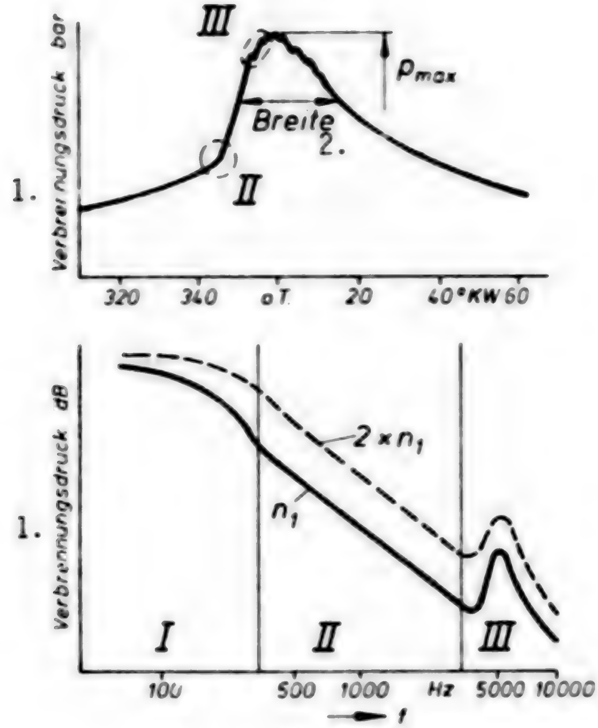


Figure 1: Qualitative interrelation between combustion pressure distribution and excitation spectrum (source: Gross, Chapter 6.2 Laermschutz, in Bussien, Automobiltechnisches Handbuch, Ergaenzungsband, 1979).

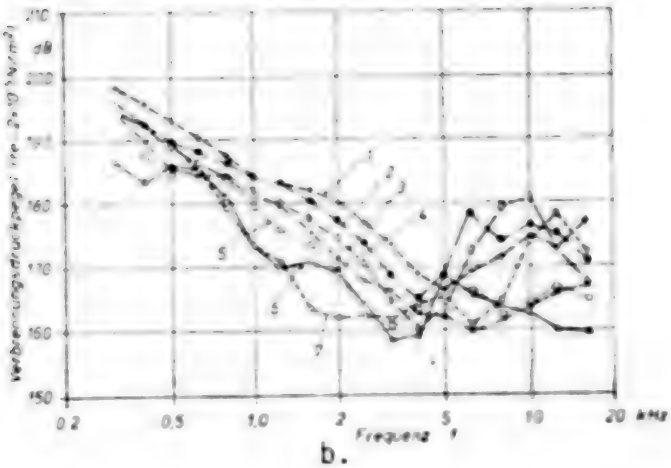
I Breadth and maximum combustion pressure
II Pressure rise at commencement of ignition
III Size and shape of combustion chamber (resonances)

1. Combustion pressure; 2. Width

body sound. Using an air-cooled V8 engine as an example, it was shown that noise-reducing measures can reduce the level by about 5 dB(A); however, a noise reduction of 10 dB(A) and more can only be achieved by full encapsulation.

A conflict of objectives arises from the environmental protection laws and the primary purpose of the engine, to create propulsion power with economically reasonable means. An aggravating feature of this conflict is that the legal requirements for environmental compatibility are competitively neutral only with respect to a particular market, but not with respect to products that are marketed worldwide.

a.



b.

Figure 2: Combustion excitation spectrum of engines with various combustion methods at rated power (source: Gross, Chapter 6.2 Lärmschutz in Bussien, Automobiltechnisches Handbuch, Ergänzungsband 1979).
1 Direct injection with air distribution, n = 3000 rpm
2 Direct injection with air distribution, n = 2800 rpm
3 Direct injection with air distribution, n = 2800 rpm
4 Constant-pressure precombustion chamber,n = 3000 rpm
5 Turbulent chamber n = 3400 rpm
6 Precombustion chamber n = 2800 rpm
7 Direct injection with wall-adjacent mixture formation n = 2500 rpm
a. Combustion pressure level
b. Frequency

In a second lecture, Prof. Essers talked about transverse piston motion in trunk piston engines, and their measurement.

The change of the arrangement of a piston from one cylinder side to another (also called transverse piston motion or secondary piston motion) occurs, at low speeds, because of the gas forces and because of the slant position of the connecting rod. Additional changes are caused by the change of direction of the connecting rod support force, in turn caused by the superposition of inertial forces. At high speeds, a piston can change sides eight times within one overall four-stroke cycle.

Since the change of sides generally takes place very rapidly, the piston can strike against the cylinder wall in impact-like fashion. This will affect mechanical motor noises and, under some circumstances, the water-carrying cavitation of the cylinder pipes, and the mechanical stress of

the piston. Because the gas force dominates, the most intense piston impact generally occurs at the ignition dead center region. However, at higher speeds, the change of position in the area of the bottom dead center becomes more significant.

The cylinder vibrations excited by the piston impact are therefore also caused indirectly by the gas pressure and consequently by the combustion. Through the conduction of body sound, these vibrations reach the surface of the housing, where air sound is then radiated. The possibilities for reducing piston impacts consequently are not limited to constructive measures at the piston itself, such as control pistons, piston play, slip curve, position of the piston pin, position of the center of gravity of the piston, rod elasticity, restriction of the crankshaft motion, etc. Rather, further possibilities also lie in the combustion process, which should have the smallest possible pressure gradient and a low peak pressure.

The piston design which is optimum from the point of view of noise was determined in a series of experiments. The measurement of transverse piston motions is also significant here. Known methods are distinguished by the manner in which the path is measured: those with capacitive distance measurement between the piston and the cylinder, and those with inductive distance measurement. Methods which work with sensing pins combined with strain gauges can be used at lower speeds. Lever systems are generally used for transmitting the measured values. The system shown in Figure 3 is known as the "Mahle System" and is widely used today. Levers 1 and 2 carry the flexible measurement lines, which lead from the coils in the moving piston to the outside. Lever 2 is pivoted at the piston pin. In principle, the following perspectives are important for lever transmission systems:

- The levers belonging to the transmission system should influence the transverse motion of the piston as little as possible.

- The engine changes required for installing the levers should be of the smallest possible extent.

- The bending stress of the measurement line should be as small as possible and the support of the lines in the levers should be as effective as possible, so that the permitted top speed or the running time at a prescribed top speed, until the measurement lines fracture, will have satisfactory values.

- The mass ratio in the area of the connecting rod should be affected as little as possible by the levers.

- The arrangement of measurement coils and of the connecting lines in the piston, especially in the area of the piston rod, should influence the local mass ratios and the rigidity of the rod as little as possible.

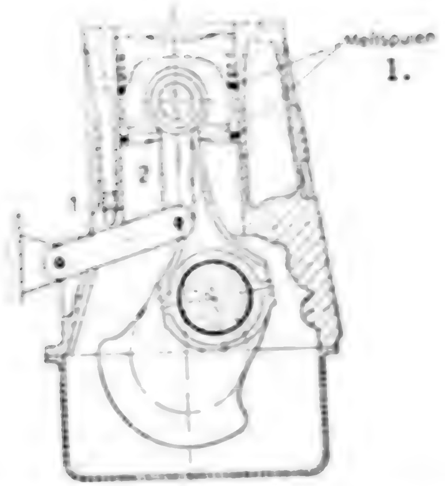


Figure 3: Inductive method for measuring the piston secondary movement with piston-mounted coils and a lever system as carrier of the instrument leads (Mahle System)

1. Measurement coils

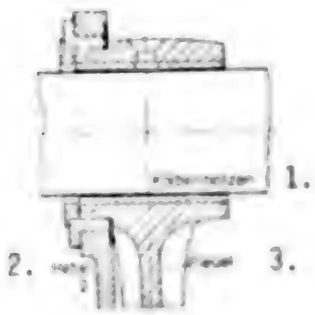


Figure 4: Bearing of the beam (lever 2) on the small connecting-rod eye (source: IVA, Brucker (unpublished))

1. Piston pins
2. Lever
3. Piston Rod

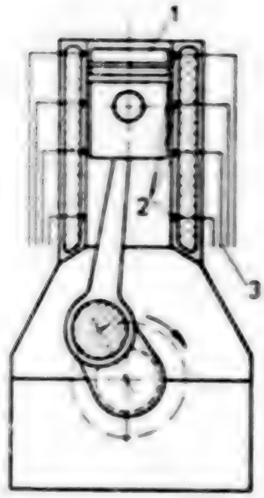


Figure 5: Inductive method for measuring the piston secondary movement with cylinder-mounted coils (source: Essers, Messtechnische Untersuchung der Kolbenquerbewegung in Verbrennungsmotoren, Habilitationsschrift, RWTH Aachen 1969)
1 Light-metal pistons
2 Measuring coils mounted in the cylinder
3 Fixed leads of the measuring coils

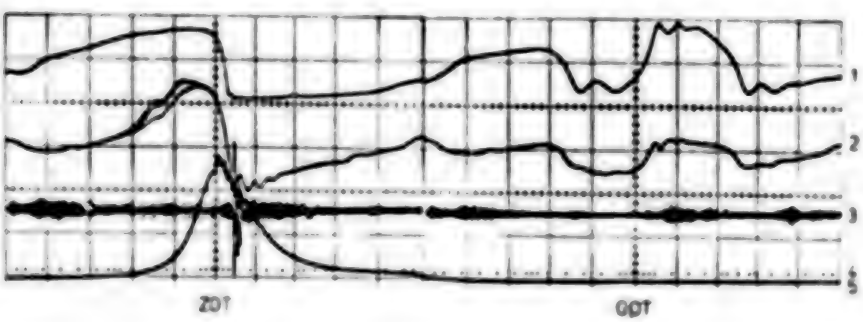


Figure 6: Record of a piston lateral movement measurement on a car diesel engine with piston-mounted measuring coils (source: IVA, Brucker (unpublished))
1 Cross path on the top edge of the piston shaft
2 Cross path on the bottom edge of the piston sha
3 Vibration (acceleration) of the cylinder lining
4 Crank angle marking
5 Cylinder pressure

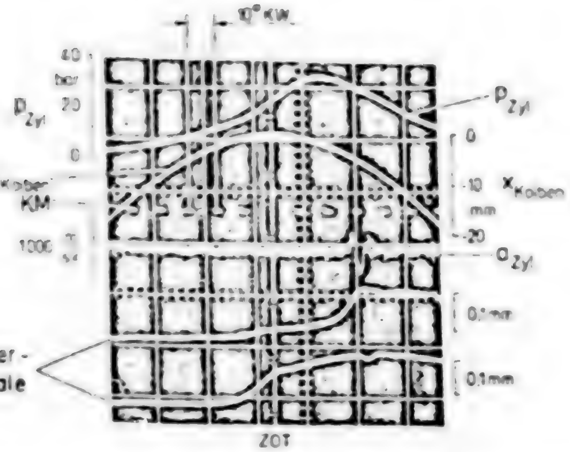


Figure 7: Record of a piston lateral movement measurement on a car Otto engine with cylinder-mounted measuring coils (source: Essers, Messtechnische Untersuchung der Kolbenquerbewegung in Verbrennungsmotoren, Habilitationsschrift, RWTH Aachen (1969)

1. Piston lateral path signals

At the Institute for Internal Combustion Engines and Working Machines (IVA), Stuttgart University, Director: Prof. Dr. Ing. E. W. Huber, it was proposed to mount the lever at the small connecting rod eye. This proposal was based on the Mahle system, and was implemented as shown in Figure 4. Such systems provide a transverse path signal that is fixed in the piston. The process with measurement coils that are fixed in the piston was proposed and used by the lecturer (Figure 5). After the measurements are converted by calculation, this process can also deliver a signal that is fixed in the piston. An advantage of this coil arrangement is the fact that the method is independent of speed, because no moving transmission system is necessary. Furthermore, this measurement method is especially suitable when various pistons are investigated in the same engine as regards transverse piston motion. Figure 6 shows a characteristic measurement record of a measurement of transverse piston motion with coils fixed in the piston. Figure 7 shows such a measurement with coils fixed in the cylinder.

Emission of Pollutants

Another important criterion for environmental pollution, besides the emission of noise, is the emission of pollutants from diesel engines. In his lecture, Dr. Ing. Hardenberg (DB) (Daimler Benz) treated charge cooling in vehicular diesel engines and its favorable effect on the emission of pollutants.

The utilization of a charge cooling system is not limited to highly charged engines, where such a system has already been used for a long time to reduce thermal load. Charge heat exchangers for cooling the charging air at high load and for heating it at low load have already been used with vehicular engines, when spontaneous ignition in multiple fuel operation was required or when e.g. the HC emission under partial load and when idling was particularly severe. With present vehicular diesel engines, the charge cooling system is becoming more and more interesting for different reasons.

Increasing the average pressure requires increasing the density of the air in the cylinder. On the one hand, this can be achieved by increasing the charging pressure, but on the other hand also by lowering the temperature of the charging air. However, the increase of density, originally obtained after the charge cooler,cannot be completely converted into an increase of the charge as delivered, because the large temperature differences between the cooled charging air and the engine walls leads to increased heat exchange. A portion of the density increase is thus lost again. With turbocharging engines, the lowering of the charge air temperature furthermore causes the loss of a portion of the chargine pressure (reduction of the energy available at the turbine).

Charge cooling therefore should frequently not be regarded as the primary means for increasing the density of the cylinder air; it has other advantages. At low speeds and at high load, a relatively small charge cooler, which is matched to this load condition, considerably reduces the emission of black smoke. A cooler that is properly dimensioned also makes a positive contribution to extra torque at low speeds.

By lowering the combustion temperature, charge cooling has a favorable effect on nitrogen oxide emission at high speeds and high loads. This is especially true when outside air is used to cool the charge. On the other hand, if the charging air should also be heated at particular operating points, cooling by the engine water can have advantages. The size of the cooling unit is suitably determined by the two criteria of smoke reduction and of reduced emission of nitrogen oxides; both factors are influenced in the same sense. It is here economical to exhaust only about 80 to 90 percent of the possible gain (Figure 8). The side effect of reducing fuel consumption is not decisive for the design of the cooler power, because only a two to three percent improvement is possible.

Especially with supercharged vehicular diesel engines, the charge cooler has proven itself as a means to meet the more severe requirements for environmental compatibility.

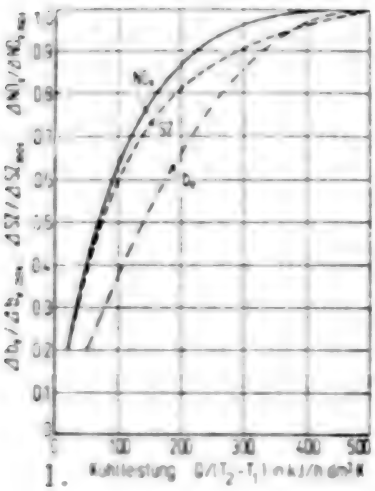


Figure 8: Influence of the performance of booster air cooling on improvements in regard to smoke, fuel consumption, and nitric oxide emission (source: Daimler-Benz AG)

1. Cooling power

Exhaust Gas Turbocharging - Not Without Problems

More and more supercharged vehicular diesel engines are today offered on the market. In many cases, the point is not that these engines in principle are superior to naturally aspirated engines for the purpose for which they are intended. In many comparison criteria, starting with the power-to-weight ratio, continuing through construction costs, and up to their dynamic behavior - a properly used, optimally matched naturally aspirated engine need not be inferior, as Dipl. Ing. Tholen (KHD) reported in his lecture.

However, supercharging - and preferably exhaust gas turbocharging - offers basic advantages for the manufacturer who wishes to implement various power capabilities in a single series of engines, and who does not wish to pursue the route of increasing power by increasing the number of cylinders. In such construction series, the basic engine, in its naturally aspirated version, is often mechanically not fully loaded. A load reserve then still remains for a more powerful, supercharged variant. The decisive factor in selecting a supercharged vehicular diesel engine therefore often is not the positive side, which this type of engine can have for the operator, but rather the absence of an alternative version in the desired power class. The supercharged engine, compared to a naturally aspirated engine of the same power, has

more efficiency, that is a better specific fuel consumption, especially in the area of high load and strong supercharging.

Furthermore, as a rule, such an engine also develops less noise. The higher combustion chamber pressures and charge temperatures at the compression end yield small ignition retarding times and consequently favorable preconditions for "soft" combustion.

Combustion noises can thus be reduced. Intake and exhaust noises are likewise reduced by an exhaust gas turbocharger. A reduction of speed will affect power, but this can be compensated by raising the average pressure. Such a reduction of speed also noticeably decreases noise emission.

Depending on the installation of the engine, it may be advantageous that the specific construction volume of the turbocharged engine is, as a rule, more favorable. These advantages of the supercharged engine as compared to the naturally aspirated engine are accompanied by properties which may prove disadvantageous in particular cases:

- NO_x emission at high load and high speed is more unfavorable, if the charging air is not intensely cooled,

- Higher emission of black smoke in the lower speed range at high load and when accelerating (delayed start-up of the turbocharger),

- Starting behavior and partial load behavior are less favorable (ε smaller than with the naturally aspirated engine),

- The torque behavior at low speeds is unfavorable if the supercharger is designed for maximum power,

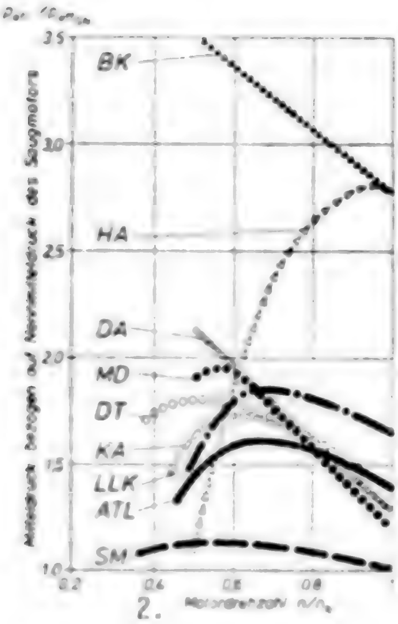
- Dynamical behavior: poor starting and accelerating behavior in the low speed range, can often be compensated only by more elaborate transmissions,

- The motor braking action is only as good as with a naturally aspirated engine of the same displacement

Developments are tending to soften or eliminate these disadvantages. Promising superchargers deliver the highest possible charging pressure even at low speeds, but do not generate an excessive rise in the upper speed range. An exhaust control before the turbine, which avoids this large pressure rise, is used in many cases. Charge cooling also seems to be becoming more significant for vehicular engines.

The following promising further developments were mentioned (see Figure 9):

1.



2.

Figure 9: Comparison of the torque characteristics obtainable approximately with different supercharging methods: (source: Killmann, VDI Berichte No. 238, 1975).

SM Suction motor
ATL Exhaust gas turbine supercharging
LLK Exhaust gas turbine supercharging with booster air cooling
KA Combined supercharging according to Cser (MAN)
DT Pressure wave exchanger Comprex (BBC)
MD Maxidyne (Mack Trucks)
DA Differential supercharging (Perkins)
HA High supercharging with reduced compression ratio
BK High supercharging with combustion chamber (Hyperbar)
(all mean pressures related to 7.2 bar)

1. Average pressure relative to rated average pressure of the naturally aspirated engine
2. Motor speed n/n_N

- Register supercharging (the parallel connection of superchargers in speed steps),

- Two-stage supercharging (series connection of two superchargers, exhaust control with the high pressure stage),

- Combined supercharging after Cser (using the gas oscillations in the lower speed range),

- Maxidyne process: matching the supercharger to low engine speeds, giving up power at high speed, extreme torque increase in the lower speed range,

- Comprex pressure wave exchanger: excellent dynamical behavior, no retardation effect when accelerating, excellent torque behavior at low speeds,

- Hyperbar process: additional burner, by means of which the supercharger can be driven as a gas turbine independent of the engine; good possibility at considerable expense, and therefore less suitable for vehicular engines.

Ing. (grad.) Kloeber (KKK) (Kuehnle, Kopp, and Kausch) reported on progress in matching exhaust turbochargers to vehicular diesel engines. Increasing the effective average pressure, especially in the region of lower engine speeds, is a constant and important task in the development of vehicular diesel engines. The exhaust gas turbocharger with high-rate operation can make an important contribution to this. If the compressor and the turbine are designed so that their most favorable efficiencies lie in the region of the required torque maximum, the desired torque increase in the lower speed range can be achieved. An improvement in the rotor bearing, that is a reduction of the turbocharger friction work, supports this trend.

The use of exhaust turbochargers with blow-off valves on the turbine side, in combination with a special design of the compressor wheel, facilitates the desired throughput characteristic: high charge pressure at low engine speed and a small rise of pressure and throughput at high speeds (Figure 10). For good acceleration behavior, it is often important to work with a small turbocharging set, which has a smaller moment of inertia and consequently has a favorable effect on dynamic behavior. During the further course of the lecture, the speaker discussed the interrelationships between the engine and the turbocharger as well as the important information which results therefrom for the manufacturers of superchargers. Especially important factors for the choice of supercharger are the injection equipment, the combustion process, the engine geometry and consequently the calculable air demand. The physical relationships necessary for this were given in terms of formulas. Correction coefficients, which take into account the dynamical behavior of the engine, were reported in the form of diagrams.

A reliable analytic supercharger design requires precise knowledge of turbine behavior in high-rate operation. Intensive studies are currently in progress for this purpose.

Modern Car Diesel Engines - Products of Systematic Studies

The objectives for a modern diesel car must retain the specific advantages of the diesel engine - low fuel consumption, high lifetime, and freedom from troubles - and at the same time must attempt to eliminate

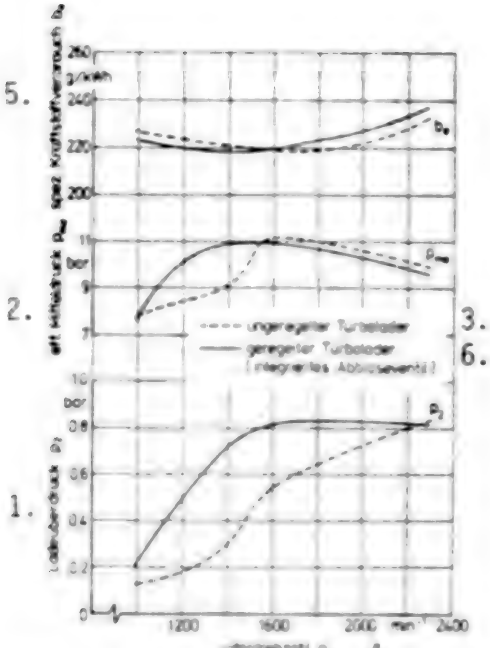


Figure 10: Characteristic values of an engine with regulated and unregulated turbosupercharger (source: Aktiengesellschaft Kuehnle, Kopp and Kausch)

1. Supercharge overpressure p_2
2. Effective average pressure p_{me}
3. Unregulated turbocharger
4. Engine speed n_M
5. Specific fuel consumption b_e
6. Regulated turbocharger (integrated blow-off valve)

its disadvantages - inadequate dynamical driving behavior, bothersome noise.

Representing Dipl. Ing. Hofbauer (VW) (Volkswagen), Dr. Ing. Kuck (VW) explained the route from system-analytic studies to mass-production maturity, using as an example the Golf diesel, which has by now become widespread. Based on a study of the combustion process, the motor with a divided combustion chamber was given the edge over a direct injection model. The reason for this was the more favorable emission of pollutants and the higher possible speed level. Among the chamber engines, a decision was made in favor of the whirl engine method, because better fuel consumption was expected.

Because of the high compression, and its associated small compression volume, severe requirements are imposed on production tolerances. For economic reasons, carburetor engines require a large extent of similar parts. This could be achieved by a purposeful selection of parts (from total production) for the diesel engines and by introducing three cylinder head gaskets of various thickness. By appropriately guiding the diesel process, peak pressures were reached which lie only slightly above the maximum values recorded for carburetor engines, taking into account the cyclic fluctuations. In this way, higher stress on the propulsion unit is avoided for the diesel engine.

By means of a large wrap angle and a tight guidance of the toothed belt, which drives the camshaft, it is possible to prevent the belt from skipping under extreme conditions. With the small distance between the piston and the valves at the upper dead center, this could lead to engine damage. Among the experimental results, the extremely favorable fuel consumption should be especially mentioned.

Special Measurement and Test Stand Techniques

Diesel engine exhaust gases can appear with certain types and under certain operating conditions. The smell of these gases is often sensed as bothersome. As the diesel engine is beoming more widespread, anti-exhaust measures are becoming the object of increased interest.

Dr. Ing. Hardenberg (DB) reports measurement possibilities for investigating the exhaust gas smell of diesel engines.

The objective is to detect the components of the exhaust gas which are relevant for smell, to quantify their effect on the smell of the exhaust, to clarify the mechanism of their generation, and finally to derive from this the proper remedies. At the present time, this objective has not yet been quite reached.

Because the human sense of smell is so very subjective, a quantity evaluation of the intensity of an odor can only be the result of a statistical treatment of a rather large number of experimental subjects.

In making olfactory determinations of the intensity of the odor, exhaust gas is mixed with the air, and the average value of the perception threshold is determined.

Gustatory intensity determinations yield results more quickly. In this case, water with exhaust gas bubbles is tasted. The procedure is quite simple, but the result can be quantified only with difficulty.

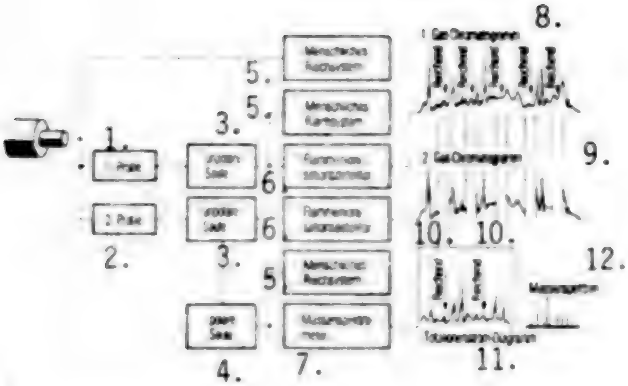


Figure 11: Odor recognition and identification system (source: Daimler-Benz AG)

1. First specimen; 2. Second specimen; 3. Non-polar acid; 4. Polar acid; 5. Human olfactory system; 6. Flame ionization detector; 7. Mass spectrometer; 8. First gas chromatogram; 9. Second gas chromatogram; 10. Odorous; 11. Total ion current diagram; 12. Mass spectra

Both procedures have in common that they provide information concerning the character and generation of the odoriferous materials. They consequently likewise provide no information concerning promising anti-smell measures. But they are an important aid for evaluating the state of development.

Other measurement methods are based on measuring other groups of materials, which can be more easily described, as representative for odoriferous materials (e.g. measurement of aldehyde emission). Such materials in themselves need not be decisive in causing odor. One must presuppose that they are generated under the same conditions as the odoriferous materials, and therefore occur in proportion to them. However, this presupposition is justified only rarely, and the applicability of this method is therefore limited.

Odor analysis is still at the very beginning of development. Here the relevant materials are selected, quantified, and identified as much as possible (Figure 11).

The analytical method presented uses the methods of gas chromatography and of mass spectrometry. But parallel olfactory measurements can at this time not yet be dispensed with.

The odoriferous materials contained in the exhaust gas can be separated, can be arranged according to their characteristics, and finally can also

be measured quantitatively. Identification of these materials is difficult and in some cases impossible.

Evaluation of a large number of individual results is hoped to provide a correlation between the quantities of different odorous materials and the intensity of the overall smell.

Previous exhaust studies with this very sensitive and discriminating analytical method have shown that more than 100,000 odoriferous materials can occur in the exhaust gases of diesel engines. However, a single gas chromatogram - which is valid for a particular type of engine and for a single load condition - always exhibits only about 25 odor-related materials.

Dip. Ing. Claassen (AVL) reported on the high specialization of test stand technology for internal combustion engines. The idle time of production test stands should be kept as small as possible, which necessitates automating the interchange of engines. In this case, it should take only minutes to change the engine. On the other hand, with research and development test stands, changing the engine requires more time, because of the more flexible mechanical construction. Standardization of feeds and exhausts can be achieved here only to a certain extent.

The development of computer technology and the prices of electronics today makes it generally possible to automate the test stand control, the data acquisition, and the data interpretation. The data display unit, the plotter for graphic display of measured results, as well as a data bank - in order to have complete comparability with previous measurements - are sensible devices for development test stands. A sophisticated monitoring system to protect the prototypes, which often are quite valuable, likewise is part of the equipment. The simplest possible operation, combined with high operating reliability, is a primary factor with a production test stand. A computer should be connected with such a test stand, in order to facilitate statistical evaluation.

After these general considerations, the speaker discussed the measurement of several important engine variables. With smoke measurement, the measurement by the filter method now as before competes with purely optical measurement methods. By varying the specimen extraction times with an integrated evaluation, the filter method can measure the exhaust gas turbidity during dynamical processes, such as e.g. occasional soot bursts during acceleration.

Two possibilities were mentioned for angular acceleration measurements: On the one hand, the arrangement of two piezoelectric accelerometers, which are arranged on a disk with the same distance from the axle, and which are connected so that they deliver an analog signal proportional

to the angular acceleration. As an alternative, a digital measurement of rotational vibrations was presented, which is based on the measurement of the time between crankshaft marks.

One of the most important measured quantities in the engine is the pressure in the combustion chamber. The state of the art here is the piezoelectric combustion chamber pressure gauge. The p_i meter was presented as a modern evaluation unit for the pressure signal. The combustion chamber pressure is available in one degree KW steps. In a microprocessor, it is converted into the mean indexed working pressure. A single working cycle can here be used as the basis for the calculation or, as is particularly advantageous with naturally aspirated engines, with their characteristic pressure fluctuations, up to 64 cycles can be used to form the average.

During the further course of the lecture, measurement devices were presented for determining compression, especially for diagnostic purposes, for determing the pressure in the ejection lines, and for determining the beginning of delivery.

Following this lecture, the participants had an opportunity to visit the Institute for Internal Combustion Engines and Vehicle Studies of Stuttgart University. This is a new facility and has been used for only a few months. There the participants could see in action several of the experimental and measurement devices that had been discussed. The Institute exhibited the newly installed automatic engine test stand of the AVL. The same manufacturer used a research engine to demonstrate rapid data acquisition and evaluation. The crankshaft angle measurement device, which permits resolution of one-tenth degree, as well as the p_i meter, could here be observed in practical application.

Bruel & Kjaer Company offered an invention in acoustic measurement technology. At a demonstration test stand, it exhibited the working process with a real-time analyzer. Another short lecture from Karlsruhe Nuclear Research Center concerned wear measurement with radionuclides and their application to internal combustion engines.

Finally, the course participants were invited to visit with Robert Bosch GmbH in Stuttgart-Feuerbach. Besides a presentation of mass-produced diesel cars, the program included inspection of test stands and production equipment (parts production, assembly and installation of diesel injection pumps).

Within the framework of this company visit, the topics "Modern Diesel Injection Systems" and "High Pressure Injection, Exhaust Gas Recycling" were discussed. It became clear that the foreseeable restrictions

imposed by exhaust gas legislation, especially in the USA, will no longer be so easily fulfilled by presently produced diesel engines. Further reductions of limit values for NO_x and soot emission do indeed also represent an obstacle for diesel engines. Novel ideas and considerable effort will be required to overcome this obstacle.

8348
CSO: 3102

EXPERIMENTS WITH ELECTRONIC AUTO GUIDANCE SYSTEMS

Bonn DIE WELT in German 8 Dec 79 p 21

[Article by W. Wuttke: "Onto the Right Route With Chirping"]

[Text] No sooner is autobahn exit 1130954 behind us when the little box on the instrument panel begins to chirp. At the same time symbols light up on the mini-screen which give commands to take the next exit, turn, and try again.

Which is what we obediently do. Not until we have in fact left the autobahn on the right exit is the little marvel satisfied and gives the go-ahead: "Please observe the route signs" shows up on the little screen. The route sign in front of us points to Castrop-Rauxel, and that is exactly where we were planning to go when we started out and punched in 1130945 on the keyboard of the device.

The name of the "electronic miracle" is ALI, an abbreviation for "control and information system for automobile drivers."

ALI's chirping soon turned into a familiar noise. It chirped when we once got too close to another car, loud and distinctly. At all on- and off-ramps on our route the electronic pilot made a noise; in addition, an arrow appeared which assured us that we were on the right road. Once when we were driving faster than permissible, having forgotten energy conservation altogether, it promptly gave us an acoustic ticket.

But that is not all there is to ALI's capabilities: the device had calculated the distance driven, the average gasoline consumption and the average speed. In addition, it can warn of traffic jams which the police do not even know about and also of fog and slippery conditions. Several routes, which are often taken, can be programmed (maximum of nine). It only takes a push of a button and the electronic chirper delivers the driver to his destination using the best route. Otmar Pilsack of the Blaupunkt Co, which was involved in developing the device, describes the primary tasks in this way: "ALI practically takes over the tasks of an advance route marker."

Big Brother Comes Along

Pilsack explains that "ALI is, of course, not static like the route sign, but rather constantly receives data via a center and can thus vary the route." By means of a ferrite antenna on the bumper guard and contacts in the roadway the receiver in the ALI automobile receives information from a computer center which constantly monitors and predicts traffic conditions.

Of course, with so much electronic equipment in the automobile, one automatically thinks of George Orwell's "Big Brother." Why should it not be possible for all the ALI pilots to transmit a code number and in this way the route of every automobile can be followed. Theoretically it is even possible that the control center can stop the engine ignition with ALI. Of course, that would mean hard times for auto thieves, but would also make the electronic policeman possible. In the age of microprocessors it is even conceivable to check one's bank balance at one's bank with ALI. Perhaps it will even be possible then to pay the telephone bill right away.

According to Peter Ruehenauffer, project director of the Rhineland TUeV [FRG automobile inspection], all this is currently "not possible because the capacity of the center at the Recklinghausen agency in charge of autobahn maintenance is not at all adequate for this." For the time being they are busy testing ALI in a large-scale experiment in the Ruhr district on 100 kilometers of autobahn. Ruehenauffer says: "Basically, we first want to test here the problems which accompany the new system. ALI is not the only design for individual guidance devices."

The devices were installed in the automobiles of 400 test drivers who must report in 1 year how they liked ALI. Ruehenauffer says: "If everything goes well, then in 3 years, at the earliest, we can think about installing ALI in automobiles." Pilsack figures that "when there is mass production, the cost will be about DM300."

In Ruehenauffer's optimistic opinion "ALI's strength is undoubtedly the capability of individual guidance. Above all else, with large events it would be possible to clear up traffic jams more quickly."

Of course, in the ALI age there will no longer be any "secret paths," because electronics can find the way only where cables have been laid. In fact, some test drivers, who all of a sudden were guided to their work in a way that was different from the usual, have already had to find that out. Anyway, the system is intended only for congested areas, as Ruehenauffer explains: "The investment is worthwhile only in such instances; that is also where the danger of traffic jams is greatest."

Thus, even in the immediate future good roadmaps will still be necessary. Until ALI is put into production some real disadvantages should be corrected: In its present form the indicator is too big and too far removed from the

driver. It should then be integrated into the instrument panel. It is also questionable whether a total of 10 symbols do not confuse the driver more than they help him. The symbols are, of course, foolproof, but in order to orient himself the driver must then glance at the screen--and given the fast driving on the autobahn this is not to be recommended.

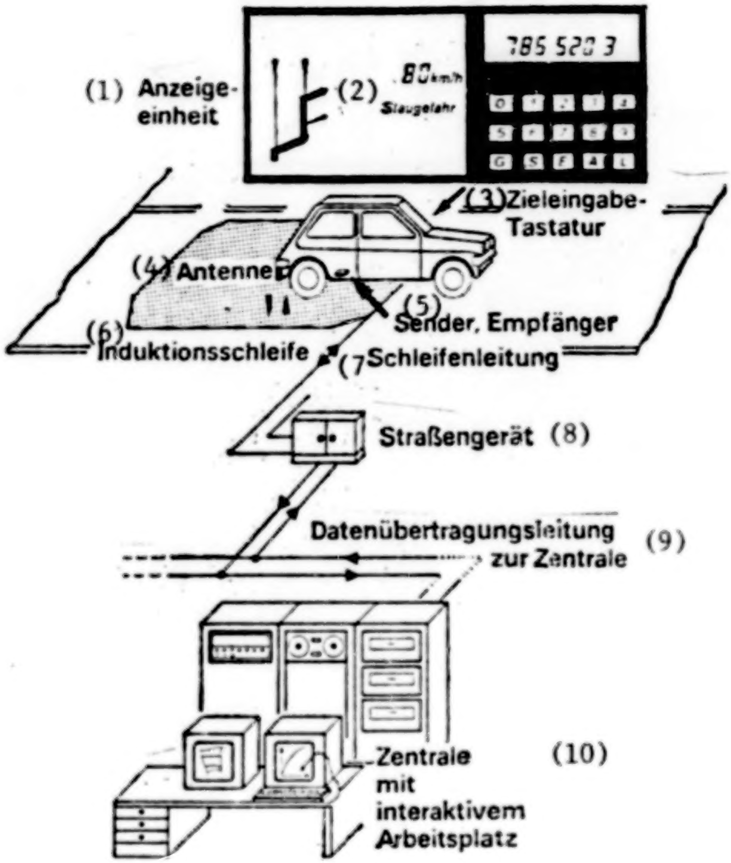
Indicator Is Still Too Large

What bothered us the most was the chirping noise which announces every display. Why it chirps when you are on the right road seems illogical. After all, you do not grab the map at every exit just to be sure that you are on the right road. Finally, we wondered whether driving with ALI will really still be a pleasure or whether it will be as much fun to ride a streetcar.

Until ALI becomes a reality some things could be done, independently of the large-scale experiment in the Ruhr District, to make the autobahns safer: For example, there is the traffic radio, which should at long last get a uniform frequency throughout the FRG. It should at the same time be controlled from a center in order to transmit reports of trouble more quickly. In addition, more alternate route markers could be installed at junction points, such as in the Rhine-Main region.

Japanese technicians have also developed a system similar to ALI. In the center of Tokyo cables were laid in an area of 28 square kilometers. According to Ruehenauffer, they are, of course "substantially more delicate than our telephone cables with which the outer stations are connected with the central office."

But the "Cac System" can do more than ALI. In addition to driving instructions the devices warn of zebra stripes, and orders the driver to stop to clear the way for an ambulance if need be. The large-scale Japanese experiment was supported primarily by the electronics industry and the automobile companies. Toyota alone provided more than 1,[illegible]00 automobiles. In all, the Japanese experiment cost DM5.3 billion. ALI's costs are by way of comparison low: the test phase is consuming DM16 million.



Key:

1. Indicator unit
2. Danger of congestion
3. Destination input keyboard
4. Antenna
5. Transmitter, receiver
6. Induction loop
7. Loop line
8. Road equipment
9. Data transmission line to the processing center
10. Processing center with interactive work position

Caption:

This is how ALI works: Induction loops which are embedded in the roadway send information to automobiles in hundreths of seconds.

12124
CSO: 3102 END

END OF FICHE

DATE FILMED

5 FEBRUARY

[redacted] '80

D.D